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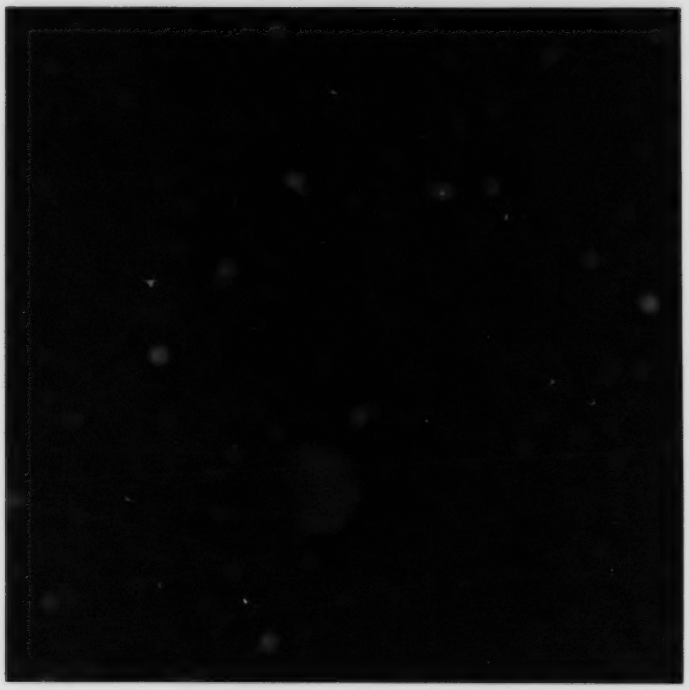

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89-03326/

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Its primary objectives are to assist in the development and maintenance of timber supplies sufficient to ensure the long-term viability of the forest industry in Manitoba; to promote the efficient utilization of the forest resource in Manitoba; and to contribute to the economic development of the Manitoba forestry sector.

The Agreement comprises four programs: Forest Renewal; Intensive Forest management; Applied Research, Technology Transfer and Opportunity Identification; and Public information, evaluation and administration. These programs are managed by a joint Directorate and are implemented by the Canadian Forestry Service and the Manitoba Forestry Branch.

L'Entente Canada-Manitoba sur la mise en valeur des ressources forestières est financée à parts égales par les gouvernements du Canada et de Manitoba, et a cours du ler avril 1984 au 31 mars 1989.

Ses objectifs principaux sont favoriser le développement et le maintien de l'approvisionnement en bois afin de répondre aux besoins a long terme de l'industrie forestière du Manitoba's; promouvoir l'utilisation rationnelle des ressources forestières du Manitoba; et contribuer à la croissance économique du secteur forestier du Manitoba.

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EFFECTS OF AERIAL APPLICATION OF THE HERBICIDE GLYPHOSATE ON FOREST ECOSYSTEMS: PART 2 A SUMMARY OF THE 2.5 L/HA SPRAY APPLICATION 1985-1988

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Safety and Health

Report #88-5
December, 1988

Henderson, V.L., D. L. Wotton and S. F. Phillips. 1988. Effects of aerial application of the herbicide glyphosate on forest ecosystems: Part 2. A summary of the 2.5 L/ha spray application, 1985-1988. Report No. 88-5. 83 pp. plus Appendices. December, 1988.

ABSTRACT

A three-year research program was initiated in the spring of 1985 to study the direct effects of aerial application of the herbicide glyphosate on the vegetation in the boreal forest region of southeastern Manitoba near Pine Falls. Indirect effects of glyphosate on wildlife utilization of the treated habitat were also studied.

The program has been extended one year because a second application of glyphosate in 1986 was necessary to control perennial shrubs and trees not affected by the first treatment in 1985. The 1986 spray application was variable and therefore strips of deciduous vegetation still remain healthy one year later. Both treatments were applied at a rate of 2.5 L/ha by fixed-wing aircraft.

Four permanent study areas were established, two treated and two control, at Sandy River West. Standard methods were used to assess botanical and wildlife parameters. Plant abundance and physical condition were documented for each species in the vegetation plots.

Songbirds, small mammals and ungulates were studied to determine their responses to habitat alterations induced by glyphosate. There appear to be no indirect effects from the herbicide on these wildlife species. One year after the last herbicide application there was a significant difference (ANOVA, $p<0.01$) in mean total available browse between the two aspen sites. The decline in mean available browse from 1986/1987 to 1988 at the Treated Aspen site was also significant (ANOVA, $p<0.05$).

The fate and persistence of glyphosate was monitored through analysis of foliage and soil samples. Mylar sheets were used to estimate actual spray deposition but they proved to be unreliable. Glyphosate concentrations in foliage sampled immediately after spraying were below toxicity levels for animals that may consume it. Glyphosate was completely adsorbed to soil particles in the top organic layer thus preventing downward leaching. Residues in the soil decreased with time and were below detection limits by the following June.

TABLE OF CONTENTS

	PAGE
ABSTRACT	i
TABLE OF CONTENTS	ii
LIST OF TABLES	iii
LIST OF FIGURES	iv
1. INTRODUCTION	1
1.1 Study Region	2
1.2 Herbicide Application	7
2. METHODOLOGY	9
3. RESULTS AND DISCUSSION	11
3.1 Weather Conditions	11
3.2 Vegetation Assessment	13
3.2.1 Tree Stratum	13
3.2.2 Shrub Stratum	13
3.2.3 Herb Stratum	18
3.2.4 Symptomatology	24
3.3 Bird Surveys	26
3.4 Small Mammal Trapping	33
3.5 Ungulate Studies	42
3.5.1 Winter Surveys	42
3.5.2 Pellet-Group Counts	45
3.5.3 Browse Studies	47
3.6 Residue Results	57
3.6.1 Deposition	61
3.6.2 Foliage Residue	62
3.6.3 Soil Residue	67
4. CONCLUSIONS	70
REFERENCES	72
PERSONAL COMMUNICATIONS	83
APPENDICES	84

LIST OF TABLES

TABLES		PAGE
1.	Study site abbreviations.....	4
2.	Summary of the tree data from the aspen sites at Sandy River West, 1985-1987.....	14
3.	Summary of the shrub data from the aspen sites at Sandy River West, 1985-1987.....	15
4.	Summary of the shrub data from the burn sites at Sandy River West, 1985-1987.....	17
5.	Association values for indicator species, Control Aspen, 1985-1987.....	19
6.	Association values for indicator species, Treated Aspen, 1985-1987.....	20
7.	Association values for indicator species, Control Burn, 1985-1987.....	21
8.	Association values for indicator species, Treated Burn, 1985-1987.....	22
9.	Fall trapping results for Sandy River West, 1985-1987.....	34
10.	Number of ungulate pellet groups counted at Sandy River West, 1985-1987.....	46
11.	Browse preference at Sandy River West, 1986-1988.....	48
12.	One-way analysis of variance comparing means of total available browse between treatment for each habitat and each year, Sandy River West, 1986-1988.....	50
13.	One-way analysis of variance comparing means of total available browse between years within sites, Sandy River West, 1986-1988.....	50
14.	Two-way analysis of variance comparing means of available browse of individual species each year (model: habitat x treatment), Sandy River West, 1986-1988.....	52

LIST OF TABLES continued

TABLES		PAGE
15.	One-way analysis of variance comparing means of available browse of individual species between years, Sandy River West, 1986-1988.....	53
16.	Glyphosate residues on deposition monitors and in vegetation and soil samples, Sandy River West, 1986 and 1987.....	58

LIST OF FIGURES

FIGURES		PAGE
1.	Map indicating the relative locations of the four study sites at Sandy River West in Manitoba.....	3
2.	Soils map of Sandy River West.....	6
3.	Diagram showing soil profile sampling.....	12
4.	Bird survey results for indicator species (per 40 ha) at Sandy River West (Treated Aspen).....	27
5.	Bird survey results for indicator species (per 40 ha) at Sandy River West (Control Aspen).....	28
6.	Bird survey results for indicator species (per 40 ha) at Sandy River West (Treated Burn).....	29
7.	Bird survey results for indicator species (per 40 ha) at Sandy River West (Control Burn).....	30
8.	Trapping results for 7 common small mammals (per 1000 trap nights) at Sandy River West (Treated Aspen).....	35
9.	Trapping results for 7 common small mammals (per 1000 trap nights) at Sandy River West (Control Aspen).....	36
10.	Trapping results for 7 common small mammals (per 1000 trap nights) at Sandy River West (Treated Burn).....	37
11.	Trapping results for 7 common small mammals (per 1000 trap nights) at Sandy River West (Control Burn).....	38
12.	Glyphosate residues in soils, vegetation and on deposition monitors, Treated Aspen, Sandy River West, 1986-1987.....	59
13.	Glyphosate residues in soils, vegetation and on depostion monitors, Treated Burn, Sandy River West, 1986-1987.....	60
14.	Diagram showing foliage sampling for aspen and willow.....	63

1. INTRODUCTION

Glyphosate [N-(phosphonomethyl)glycine] is a broad-spectrum, non-selective, foliar-applied herbicide. It is now marketed for silvicultural use in forest management under the brand name, Vision. Vision has the same formulation as its predecessor, Roundup. It is composed of 41% glyphosate (as isopropylamine salt; equivalent to 356 g/L of the acid, glyphosate), 15% polyethoxylated tallow amine surfactant, and 44% water or other inert substances (Monsanto Corp., 1987).

Glyphosate enters the plant through the leaves and is readily translocated to areas of meristematic activity, resulting in plant death (Caseley and Coupland, 1985; Franz, 1985). Upon reaching the ground, glyphosate binds tightly to soil particles (Franz, 1985; Knuuttila and Knuuttila, 1985). This adsorption prevents movement of the herbicide through the soil or possible toxic effects as a result of root absorption (Torstensson, 1985). Glyphosate is degraded by microbial action into the principal metabolite, aminomethylphosphonic acid (AMPA). AMPA is also biologically degradable and end products are phosphonic acid, ammonia, and carbon dioxide (Franz, 1985; Rueppel et al., 1977; Sprankle et al., 1975a; Torstensson, 1985). In plants, glyphosate acts on the shikimic acid pathway which is absent in animals (Cole, 1985). Consequently the herbicide has a low toxicity to other life forms (Franz, 1985).

Herbicides are an important tool in forest management and glyphosate has proven to be highly effective in the control of herbaceous and hardwood vegetation (Franz, 1985; Sutton, 1978).

Glyphosate is used primarily in two ways in silvicultural practices. It may be applied to prepare sites for planting conifers or to release conifer stands from competing vegetation (Newton and Knight, 1981). In both instances the objective is to suppress weed species in order to promote survival and improve growth rates of softwood seedlings (Malik and Vanden Born, 1986). The use of herbicides such as glyphosate has provided a means of dealing with the backlog of poorly regenerated lands that have accumulated over past decades. When properly applied, herbicides are a safe and economic tool that can assist the forester in sustaining and perpetuating the forest resource.

There is little information on the consequence of aerial application of glyphosate on boreal forests in Manitoba. The objectives of this study are to examine the direct effect of glyphosate on vegetation; to assess the indirect influences on utilization of the habitat by wildlife (song birds, small mammals and ungulates); and to determine the distribution, fate and persistence of the herbicide in the boreal forest environment.

1.1 Study Region

The study region, Sandy River West, is located 3.5 km west of Provincial Road 304 and north of Sandy River, in sections 27, 28 and 33 of township 23, range 9E (Figure 1). The control area is located 2.2 km northwest of the Sandy River crossing and the treated area is .5 km to the northeast. In each area, plots were selected in two forest types: a cut-over burn and a stand of young aspen. For simplicity, the names of the sites were abbreviated to initials (Table 1).

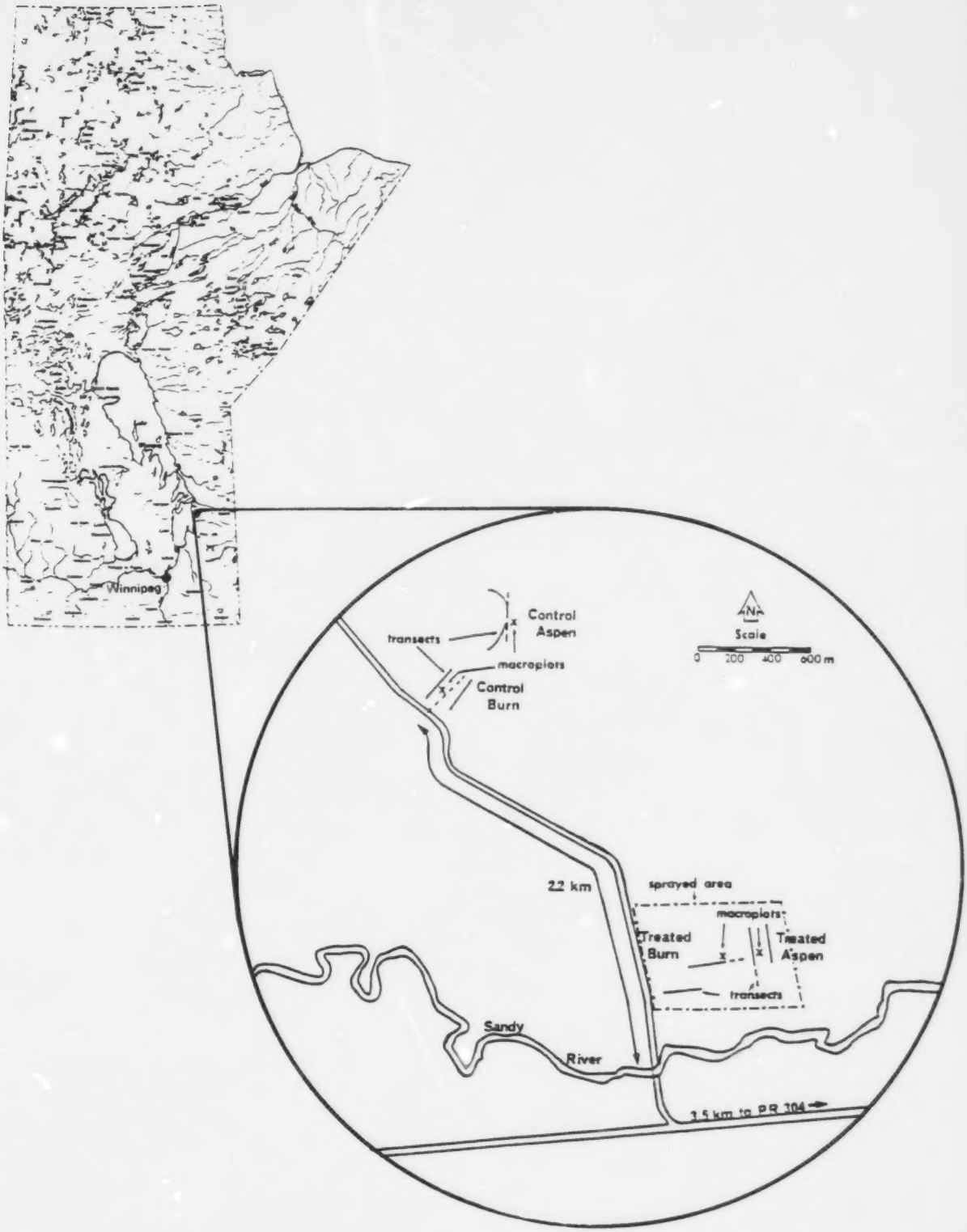


Figure 1: Map indicating the relative locations of the four study sites at Sandy River West in Manitoba.

Table 1: Study Site Abbreviations

Name	Abbreviations
Treated Aspen	TA
Treated Burn	TB
Control Aspen	CA
Control Burn	CB

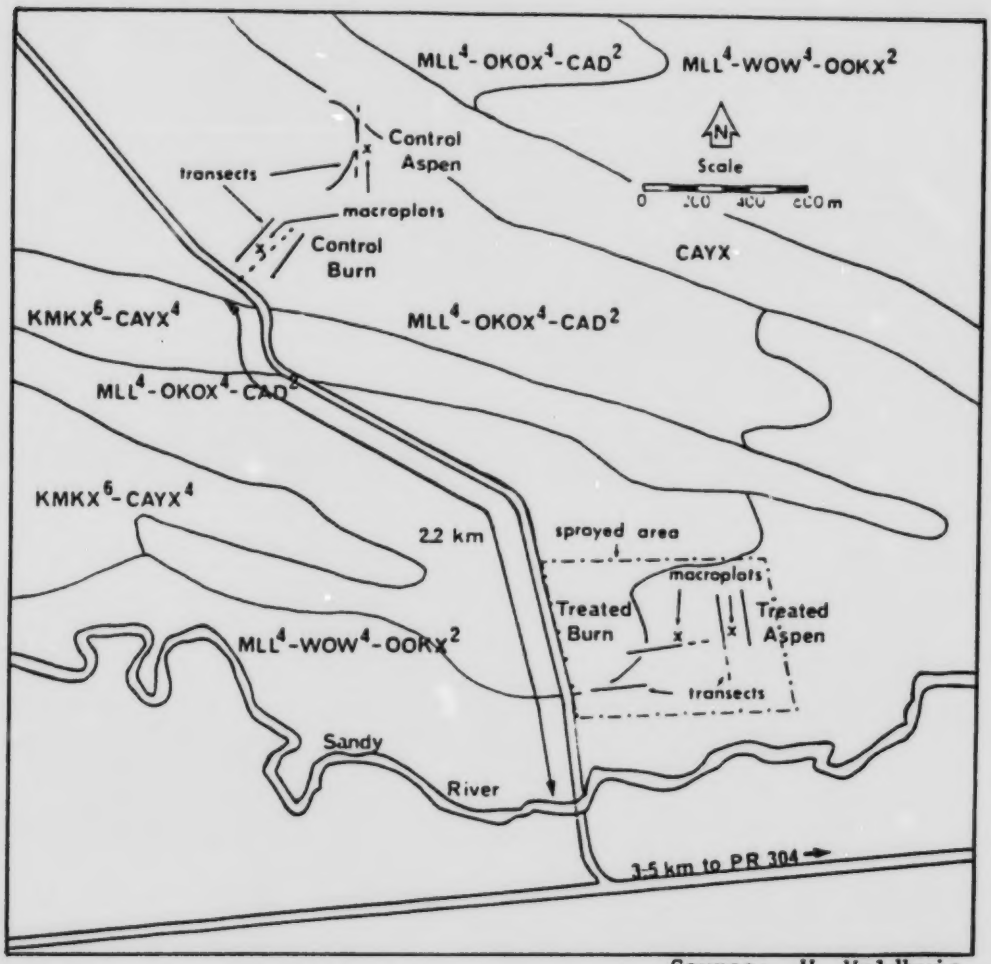
The cut-over area had been burned in 1984 and shear bladed by Abitibi-Price Inc. (Pine Falls) the following winter. Black spruce [Picea mariana (Mill.) BSP.] seedlings were planted in the summer of 1985. Scattered residual stands of spruce (Picea spp.) and small clumps of willow (Salix spp.) and aspen (Populus spp.) now dot the area. The dominant shrub species are willow (Salix spp.), rose (Rosa acicularis Lindl.), and raspberry (Rubus idaeus L.). The predominant ground cover species other than grasses, are northern bedstraw (Galium boreale L.), strawberry [Fragaria glauca (S. Wats.) Rydb.], Lindley's aster (Aster ciliolatus Lindl.), and thistles (Cirsium spp. and Sonchus arvensis L.).

The aspen stand was chosen to represent the typical N.S.R. 2 (not sufficiently regenerated) areas which were being reforested by Abitibi-Price. Trembling aspen (Populus tremuloides Michx.) is the dominant species; black and white spruce [Picea marinana (Mill.) BSP. and Picea glauca (Moench) Voss], balsam fir [Abies balsamea (L.)

Mill.], tamarack/larch [Larix laricina (DuRoi) K. Koch], and white birch (Betula papyrifera Marsh.) are the other major tree species. The shrub understory consists primarily of rose (Rosa acicularis Lindl.), high-bush cranberry (Viburnum trilobum Marsh.), raspberry (Rubus idaeus L.), saskatoon (Amelanchier alnifolia Nutt.), hazel (Corylus cornuta Marsh.) and downy arrowwood (Viburnum rafinesquianum Schultes). Northern bedstraw (Galium boreale L.), wild Lily-of-the-valley (Maianthemum canadense Desf. var. interius Fern.), Lindley's aster (Aster ciliolatus Lindl.), grasses, and strawberry [Fragaria glauca (S. Wats.) Rydb.] constitute the major ground cover species.

Sandy River West is within the Precambian Shield and is underlain by granitoid bedrock (Barr, 1956). Soil texture is generally heavy, ranging from silty clay to clay (Barr, 1956). Drainage ranges from poor to well-drained and the topography is gently sloping with occasional depressional flats and basin bogs (H. Veldhuis, pers. com. 1986).

The soil types at the control and treated plots are very similar (Figure 2). The soil at the treated sites belongs to the Malloy Series/Wanipigow River Series/Orok Complex of clay and fibric peat. The control sites have soils that are classified Malloy Series/Okno Complex/Caddy Lake Series. Generally, in both classifications, shallow organic soil covers a thin layer of fibric sphagnum peat overlying a mesic forest peat. A veneer of lacustrine sediments underlies the peat (H. Veldhuis, pers. com. 1986).



Source: H. Veldhuis

LEGEND

CAYX	Cayer Complex (mesic peat)
$KMKX^{6}$-$CAYX^{4}$	Katimik Complex (mesic peat); Cayer Complex (mesic peat)
MLL^{4}-$OKOX^{4}$-CAD^{2}	Malloy Series (clay); Okno Complex (mesic peat); Caddy Lake Series (clay)
MLL^{4}-WOW^{4}-$OOKX^{2}$	Malloy Series (clay); Wanipigow River Series (clay); Orok Complex (fibric peat)

Figure 2: Soils map of Sandy River West.

Total annual precipitation is 588.9 mm; most of it falls as rain from May to September. January is the coldest month with a mean daily temperature of -20.9°C and July is the warmest, at 18°C (Environment Canada, no date).

1.2 Herbicide Application

The treated areas were sprayed with glyphosate by fixed-wing aircraft on the evening of August 16, 1985, at an application rate of 2.5 L/ha. Results from the analysis of the vegetation, soil and deposition samples, and the vegetation damage assessment indicated that the herbicide had little, if any, effect. At the time of spraying the foliage was wet. This, combined with the heavy rain that started six hours later and continued for over 24 hours, could have washed the herbicide off the foliage before it could be absorbed. Caseley and Coupland (1985) found that the amount of moisture (dew or rain) on the leaf surface at application time is crucial as it can induce runoff of the herbicide.

The treated plots were resprayed on August 15, 1986, at an application rate of 2.5 L/ha. The spraying occurred in the early morning on a clear, calm day; light rain fell in the late afternoon.

Vegetation assessment of the treated area in 1987 indicated that the second aerial application of glyphosate was not uniform. There are strips of healthy vegetation adjacent to areas of significant kill.

From 1979 to 1981, Abitibi-Price conducted field trials with Roundup at three rates: 2.5 L/ha, 5.0 L/ha and 7.0 L/ha [.25 gal (U.S.)/acre, .5 gal (U.S.)/acre, and .75 gal (U.S.)/acre, respectively]. The 1982 herbicide assessment report stated that the 7.0 L/ha application rate was excessive because desirable results were achieved at the two lower rates (2.5 and 5.0 L/ha). Although the recommended aerial application rate is 3 to 6 L/ha (dependent on target species) (Monsanto Corp., 1987), Abitibi-Price has opted to use only 2.5 L/ha. In fact, at 2.5 L/ha 50-100% of the mature aspen trees and the majority of the aspen sucker growth were killed in recently cleared areas and 65-70% of the mature aspen trees were killed at the N.S.R. 2 sites (Keenan et al., 1982). At that time it was thought that the annual weeds and grasses which overgrow most sites within a year, were from seeds. Now it is believed the herbaceous growth is from root stock not killed because of the low herbicide rate (V. Keenan, pers. com. 1988).

The variable herbicide control which occurred at Sandy River West could have resulted from the interaction of numerous factors. Meteorological factors such as wind, humidity, precipitation (rain or dew), air temperature, and light play a decisive role in the success of a herbicide. Soil moisture, the stage of plant growth, and the application techniques can also influence the amount of glyphosate intercepted, retained, and absorbed by the foliage (Caseley and Coupland, 1985). Abitibi-Price even had spotty control on a trial site when 5 L/ha was used. Wind drift during the spray application was considered the probable cause (Keenan et al., 1982).

Also, since glyphosate is a slow-acting herbicide and its maximum long-term effect may not be realized until two years after the treatment (Malik and Vanden Born, 1986), more effects may be observed during the 1988 vegetation assessment at Sandy River West.

2. METHODOLOGY

In each of the four sites, one 100 m^2 vegetation plot was set up to study the tree, shrub, herb, and ground strata. Plant abundance was recorded for each species. Condition of the plants was documented to determine the degree of the glyphosate toxicity. Plants were classified as being healthy, chlorotic, necrotic, epinastic, crown-dead or dead. Because of the apparent poor kill at the Treated Aspen vegetation plot, another plot was set up twenty meters away in an area where visible vegetation injury was observed. The same vegetation assessment was carried out at this new plot.

Bird surveys were conducted along fixed-width transects at each site to census the breeding bird population. Thirteen bird species were chosen as indicators and their numbers and locations recorded on maps of each transect. From 1985 to 1987, surveys were run during the second and third weeks of June between the early morning hours of 5:00 and 8:30. Each transect was visited five times and at different times each morning during the course of the survey.

The small mammal population was estimated from trapping results on permanent traplines established within each study area. Three traps, baited with a mixture of rolled oats, peanut butter, and

bacon bits, were set out at each station. There were twenty stations per trapline and two traplines per study area. The traplines were maintained for three consecutive days and nights for each sampling event. Sampling took place three times in both 1985 and 1986, to determine pre-spray, immediate post-spray and 30-day post-spray populations. In 1987, trapping occurred twice, corresponding to the pre-spray and 30-day post-spray sampling times.

Ungulate studies involved estimating winter habitat and browse utilization by moose [Alces alces (Linnaeus)] and deer [Odocoileus virginianus (Zimmermann)]. Fifty 4 m^2 plots were established at each study area, and the total number of stems, the number of browsed stems, and the number of pellet groups were counted in each plot. Six primary browse species were included in the study: willow (Salix spp.), red-osier dogwood (Cornus stolonifera Michx.), trembling aspen (Populus tremuloides Michx.), white birch (Betula papyrifera Marsh.), balsam poplar (Populus balsamifera L.), and rose (Rosa acicularis Lindl.). Winter surveys were conducted two to three days after a snowfall and included snow depth, crust hardness and temperature measurements and a tally of ungulate tracks for each study area. Ungulate tracks crossing or running beside the transects were considered separate entities unless they were obviously tracks from the same animal. Track counts can indicate when use of the area occurred and the results can be used to help evaluate the browse survey data (Drolet, 1978).

Vegetation and soil were sampled four times for each of the two treatments: pre-spray, immediate post-spray, 30-day post-spray

and 10-month post-spray. Foliage was collected from aspen, rose, and ground cover species at the aspen sites but only from willow and ground cover species at the burn sites. Soil samples were taken from three levels: the surface organic layer, and 10 cm and 30 cm depths (Figure 3). Spray deposition was monitored at two levels (above the tree canopy and on the ground) at the aspen sites and one level (ground) at the burn sites for both treatments. All samples were stored in 500 g plastic honey containers and frozen until they were analysed.

A more detailed description of the sampling procedures outlined in this section can be found in the report, "Effects of Aerial Application of the Herbicide, Glyphosate (Roundup), on Forest Ecosystems: Part I Procedures Manual"; second printing by V. L. Henderson and D. L. Wotton (1987).

3. RESULTS AND DISCUSSION

3.1 Weather Conditions

Abitibi-Price's field crew recorded the weather conditions at the time of both sprays. The following conditions prevailed (V. Keenan, pers. com. 1988).

Date:	August 16, 1985	August 15, 1986
Time:	5:04-6:39 p.m.	7:20-7:31 a.m.
Temperature:	18°C	18°C
Relative Humidity:	-	70%
Wind Speed:	4 km	7 km
Wind Direction:	-	South
Sky Condition:	Overcast	Clear

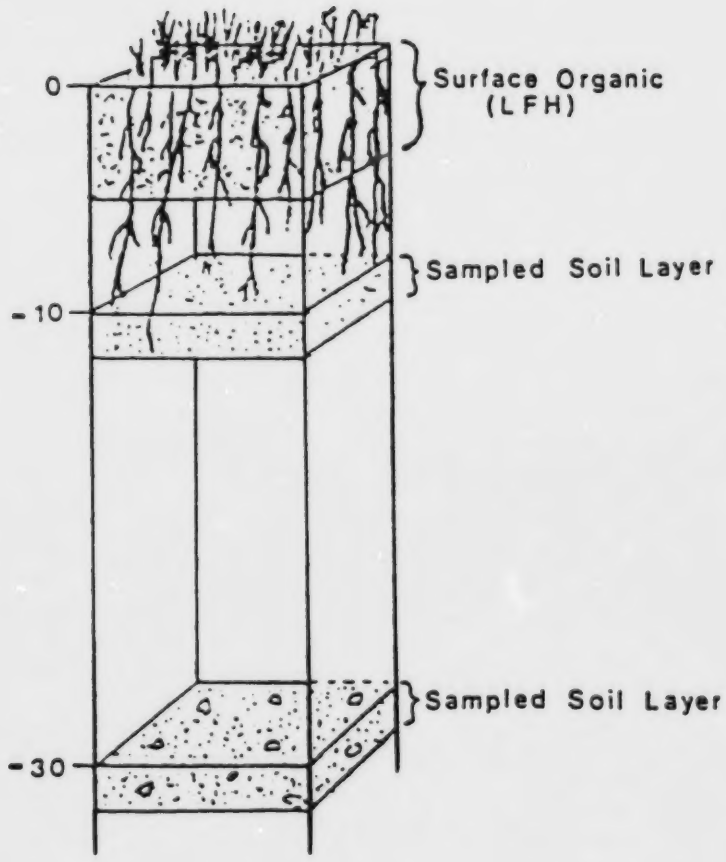


Figure 3 : Diagram showing soil profile sampling

3.2 Vegetation Assessment

3.2.1 Tree Stratum

Physical characteristics of the trees found in the aspen sites are summarized in Table 2. There were no tree species recorded in the burn sites. Three tree species were recorded in the Control Aspen and only one, Populus tremuloides Michx., in the Treated Aspen. No visible injury was apparent on the treated site after the 1985 spray application. Mortality was also light in 1987 indicating poor control from the reapplication in 1986. Similar increases in the basal area of aspen species were recorded at the control and treated sites in both 1986 and 1987. In 1988, two-years post-spray, a further increase in mortality on the treated site may occur.

The data from Table 2 indicate a poor kill from the herbicide applications. This is in keeping with visual observations made on the site during 1986 and 1987.

3.2.2 Shrub Stratum

In Table 3 the physical characteristics of the shrub layer in the control and treated aspen sites are summarized. Species diversity was greater in the treated site than in the control. Some variability is noted for Rosa acicularis Lindl. in the control site during the three years of sampling. This may be the result of minor ecological effects, sampling error, or physical damage which occurred while measurements were being taken.

Table 2: Summary of tree data from the aspen sites at Sandy River West, 1985-1987.

PLOT	TREE SPECIES	MEAN DIAMETER (cm)			MEAN HEIGHT (m)			PERCENT MORTALITY			BASAL AREA /PLOT (cm^2)			TOTAL LIVING BASAL AREA/PLOT (cm^2)		
		1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987
CA	Abies balsamea	3.40	3.70	4.20	4.00	3.80	4.00	-	-	-	9.07	10.75	13.85	471.64	497.66	624.10
	Betula papyrifera	2.55	2.80	3.60	3.25	3.65	4.50	-	-	-	10.17	12.31	20.35	-	-	-
	Populus tremuloides	2.89	2.96	3.30	3.71	3.45	4.94	-	-	-	452.40	474.60	589.90	-	-	-
TA	Populus tremuloides	3.55	3.82	4.17	4.67	5.19	5.74	-	-	0.70	702.40	813.30	955.50	702.40	813.30	955.50

Table 3: Summary of the shrub data from the aspen sites at Sandy River West, 1985-1987.

PLOT	SHRUB SPECIES	MEAN HEIGHT (m)			MEAN CROWN WIDTH (m)			MEAN NO. STEMS / SHRUBS			TOTAL SHRUBS /PLOT			TOTAL NO. STEMS/PLOT			MEAN % MORTALITY/PLOT		
		1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987
CA	Amelanchier alnifolia	1.18	1.68	1.79	0.70	0.80	0.44	2.00	2.20	1.71	4	5	7	8	11	12	-	-	-
	Betula papyrifera	1.45	1.48	2.10	0.83	0.73	0.75	2.50	3.50	2.50	2	2	2	5	14	5	-	-	-
	Corylus cornuta	-	1.00	1.00	-	0.30	0.20	-	2.00	2.00	-	1	1	-	2	2	-	-	-
	Prunus spp	0.8	-	-	0.65	-	-	3.00	-	-	2	-	-	6	-	-	-	1.96	-
	Rosa acicularis	0.98	1.12	1.17	0.57	0.68	0.53	2.34	2.65	2.46	76	65	52	178	172	128	-	10.89	17.33
	Rubus idaeus	0.79	-	-	0.30	-	-	1.87	-	-	15	-	-	28	-	-	-	14.85	-
	Viburnum trilobum	0.88	0.90	0.85	0.25	0.65	0.30	1.00	1.00	1.00	2	2	2	2	2	2	-	-	-
TA	Amelanchier alnifolia	0.88	1.00	1.17	0.45	0.43	0.42	2.14	1.67	2.00	7	6	6	15	10	12	-	1.09	-
	Cornus stolonifera	1.10	1.20	1.53	0.50	0.67	0.60	2.00	2.67	2.33	1	3	3	2	8	7	-	-	-
	Corylus cornuta	0.85	1.00	0.70	0.40	0.50	0.30	3.00	6.00	1.00	1	1	1	3	6	1	-	-	-
	Populus tremuloides	1.30	1.50	1.60	0.35	0.30	0.30	1.00	1.00	1.00	1	1	1	1	1	1	-	-	-
	Rhamnus alnifolia	1.00	1.50	1.10	0.85	0.50	0.40	1.00	1.00	1.00	1	1	1	1	1	1	-	-	-
	Ribes oxyacanthoides	0.68	0.80	0.80	0.68	0.60	0.70	3.67	1.00	3.00	3	1	1	11	1	1	-	2.17	-
	Rosa acicularis	0.81	1.00	0.86	0.46	0.43	0.45	1.43	1.88	2.22	44	34	23	63	64	51	-	10.87	13.58
	Rubus idaeus	0.79	1.08	0.75	0.34	0.40	0.40	1.43	2.00	1.50	7	4	2	10	8	3	-	3.26	2.47
	Salix spp.	1.87	1.78	1.90	0.74	0.64	0.76	3.20	3.00	2.20	5	5	5	16	15	11	-	-	-
	Viburnum refinesquianum	0.88	1.24	1.26	0.46	0.46	0.50	1.85	1.96	2.36	20	23	22	37	45	52	-	-	1.23
	Viburnum trilobum	0.95	1.05	1.00	0.50	0.45	0.60	2.00	1.50	2.00	2	2	2	4	2	4	-	-	-

At the treated site the mean number of shrub stems did not change substantially between 1985 and 1987. There was no change in the shrub composition after the herbicide applications. Similarly, height and mean crown width were not markedly changed after the spray events.

Mean percent mortality is similar between control and treated sites. The density of Rosa acicularis Lindl. varied between 1985 and 1987 on both sites, but mortality has been greatest on the control site. Similarly, the mortality recorded for Rubus idaeus L. was greater on the control site.

Table 4 provides a summary of the physical characteristics for the shrubs at the control and treated burn sites. There was similar variability in the shrub parameters measured at both burn sites. However, differences in the mortality rates of Populus tremuloides Michx. and Salix spp. in 1987 suggests some effect from the herbicide treatments. There was mortality in Populus tremuloides Michx. (9.68%) at the treated site but none at the control site. Salix spp. also had higher mortality at the treated site than at the control (12.90% vs. 4.08% respectively). The herbicide had a greater effect on shrubs at the burn site compared with the aspen site probably because there was no tree overstory at the burn site to intercept the spray.

In summary, it would appear that the two chemical applications of 2.5 L/ha of glyphosate had minimal effect on the shrub layer at both the Treated Aspen and Treated Burn sites. During the three years of monitoring, variability in the physical characteristics of shrubs on these sites appears to have been influenced by a

Table 4: Summary of the shrub data from the burn sites at Sandy River West, 1985-1987.

PLOT	SHRUB SPECIES	MEAN HEIGHT (m)			MEAN CROWN WIDTH (m)			MEAN NO. STEMS / SHRUBS			TOTAL SHRUBS /PLOT			TOTAL NO. STEMS/PLOT			MEAN % MORTALITY/PLOT		
		1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987
CB	Populus tremuloides	1.07	1.28	1.29	0.80	0.40	0.45	-	1.48	1.52	12	21	21	-	31	32	-	-	-
	Rosa acicularis	0.73	0.80	0.70	0.78	0.80	0.40	5.50	5.00	2.00	2	1	1	11	5	2	-	2.70	-
	Salix spp.	0.90	1.31	1.30	0.65	0.73	0.86	5.48	8.41	8.28	23	27	25	126	227	207	-	-	4.08
TB	Betula papyrifera	1.10	-	-	0.85	-	-	7.00	-	-	1	-	-	7	-	-	-	7.14	-
	Populus tremuloides	1.10	1.28	1.40	0.37	0.35	0.60	3.00	1.50	2.00	3	4	1	9	6	2	-	-	9.68
	Salix spp.	0.96	1.08	2.09	1.50	0.78	0.78	9.00	10.69	8.88	10	13	9	90	139	71	-	-	12.90

combination of natural ecological changes (e.g. succession) and physical disturbances as well as herbicide effects.

3.2.3 Herb Stratum

The vegetation abundance data for the herb stratum in the years 1985, 1986 and 1987 are summarized in Appendix A. Frequency, relative frequency, density, relative density, cover, and relative cover have been calculated from density and cover data collected at each of ten microplots per site in each of the three years.

To facilitate evaluation of this large data base, the association value (association value = % frequency + % cover ÷ 2) was calculated for each understory species in each study site. Association values provide a means of assessing the relative importance of a species to the site. In addition, the relative change in species composition over time can be assessed by comparing association values between years.

A large number of species are present in the herb layer. Consequently, an attempt was made to simplify the assessment by limiting the comparison to indicator species. A species was selected as an indicator if it was present in 50% or more of the 1 m^2 sampling plots (e.g. frequency $\geq$0.5) at the treated sites in 1986 (there was a greater number of species with frequencies of 50% or more in 1986). The association values for these indicator species were then compared.

The percent change (%Δ) in the association values were determined for the indicator species at each site over annual intervals (Tables 5 to 8). Species from both the herb and shrub

Table 5: Association values for indicator species, Control Aspen, 1985-1987.

SPECIES	1985	1986	1987	% Δ 1985-86	% Δ 1986-87
Shrub Layer					
Rosa acicularis	10.47	15.97	12.12	52.53	-24.11
Rubus idaeus	3.97	2.70	0.85	-31.99	-68.52
Symphoricarpus occidentalis	0.92	0.92	0.40	0.00	-56.52
Herb Layer					
Aquilegia canadensis	0.88	1.80	0.63	104.55	-65.00
Aster ciliolatus	6.35	13.55	10.50	113.39	-22.51
Cirsium spp.	3.55	1.75	0.60	-50.70	-65.71
Epilobium angustifolium	5.67	3.97	1.42	-29.98	-64.23
Equisetum sylvaticum	3.95	3.95	1.00	0.00	-74.68
Galium boreale	5.67	5.30	1.00	-6.53	-81.13
Grasses	12.30	17.30	0.75	40.65	-95.66
Maianthemum canadense	4.07	1.52	0.52	-62.65	-65.79
Mertensia paniculata	1.95	3.30	0.63	69.23	-80.91
Petasites palmatus	1.30	0.80	0.22	-38.46	-72.50
Rubus pubescens	0.97	0.80	0.30	-17.53	-62.50
Smilacina stellata	1.32	0.32	0.07	-75.76	-78.13
Viola spp.	1.27	0.92	0.60	-27.56	-34.78
Moss and Lichen Layer					
Calliergon richardsonii	1.87	2.60	0.75	39.04	-71.15
Total percent change per site				78.23	-1083.83
Average percent change				+4.60	-63.75

Table 6: Association values for indicator species, Treated Aspen, 1985-1987.

SPECIES	1985	1986	1987	% Δ 1985-86	% Δ 1986-87
Shrub Layer					
Rosa acicularis	8.12	8.87	5.30	9.24	-40.25
Rubus idaeus	7.45	4.90	1.50	-34.23	-69.39
Symphoricarpus occidentalis	2.97	2.87	0.77	-3.37	-73.17
Herb Layer					
Aquilegia canadensis	0.32	1.13	0.15	253.13	-86.73
Aster ciliolatus	3.32	4.30	1.60	29.52	-62.79
Cirsium spp.	1.40	1.45	0.30	3.57	-79.31
Epilobium angustifolium	1.70	1.13	0.88	-33.53	-22.12
Equisetum sylvaticum	0.47	1.02	0.38	117.02	-62.45
Galium boreale	5.32	5.05	1.25	-5.08	-75.25
Grasses	24.30	20.00	2.60	-17.70	-87.00
Maianthemum canadense	2.52	2.60	0.67	3.17	-74.23
Mertensia paniculata	2.22	2.97	0.22	33.78	-92.59
Petasites palmatus	2.37	2.30	0.77	-2.95	-66.52
Rubus pubescens	3.15	3.47	1.10	10.16	-68.30
Smilacina stellata	1.65	1.55	0.30	-6.06	-80.65
Viola spp.	0.47	0.95	0.77	102.13	-18.95
Moss and Lichen Layer					
Calliergon richardsonii	1.95	4.05	1.25	107.69	-69.14
Cladonia spp.	1.00	2.32	0.47	132.00	-79.74
Total percent change per site				+698.49	-1208.58
Average percent change				+38.81	-67.14

Table 7: Association values for indicator species, Control Burn, 1985-1987.

SPECIES	1985	1986	1987	% Δ 1985-86	% Δ 1986-87
Shrub Layer					
Rosa acicularis	2.25	1.90	0.88	-15.55	-53.68
Rubus idaeus	11.05	5.07	2.45	-54.12	-51.68
Herb Layer					
Aquilegia canadensis	4.50	0.40	0.32	-91.11	-20.00
Aster ciliolatus	1.25	2.20	1.60	76.00	-27.27
Cirsium arvense	3.87	5.90	1.25	52.45	-78.81
Cirsium spp.	0.40	0.47	0.15	17.50	-68.09
Epilobium angustifolium	0.70	0.63	0.30	-10.00	-52.38
Equisetum sylvaticum	1.60	1.60	0.07	0.00	-95.63
Fragaria glauca	2.32	2.35	1.45	1.29	-38.30
Galium boreale	15.92	18.00	8.85	13.07	-50.83
Geum macrophyllum	0.00	0.22	0.22	22.00	0.00
Grasses	27.65	38.45	11.55	39.06	-69.96
Lathyrus venosus	6.35	5.40	0.70	-14.96	-87.04
Maianthemum canadense	0.32	0.80	0.40	150.00	-50.00
Petasites palmatus	0.07	0.07	0.07	0.00	0.00
Viola spp.	1.13	0.00	0.00	-100.00	0.00
Total percent change per site				+85.63	-743.67
Average percent change				+5.35	-46.48

Table 8: Association values for indicator species, Treated Burn, 1985-1987.

SPECIES	1985	1986	1987	% Δ 1985-86	% Δ 1986-87
Shrub Layer					
Rosa acicularis	2.82	1.72	0.38	-39.01	-77.91
Rubus idaeus	10.25	7.20	1.25	-29.76	-82.64
Herb Layer					
Achillea millefolium	1.55	2.32	0.70	49.68	-69.83
Anemone canadensis	3.65	4.55	2.52	24.66	-89.78
Aquilegia canadensis	1.05	1.27	0.38	20.95	-70.08
Aster ciliolatus	5.02	6.25	3.35	24.50	-46.40
Cirsium arvense	4.15	2.62	0.52	-36.87	-80.15
Cirsium spp.	3.97	2.70	0.38	-31.99	-85.93
Epilobium angustifolium	12.50	6.25	1.25	-50.00	-80.00
Equisetum sylvaticum	2.85	3.50	0.63	22.81	-82.00
Fragaria glauca	6.85	7.45	2.10	8.76	-71.81
Galium boreale	1.40	1.97	0.47	40.71	-76.14
Geum aleppicum	1.65	2.30	0.00	39.39	-100.00
Geum macrophyllum	0.15	2.37	0.92	1480.00	-61.18
Grasses	20.75	38.35	4.95	84.82	-87.09
Lathyrus venosus	0.15	1.20	0.38	700.0	-68.33
Maianthemum canadense	0.40	1.13	0.30	182.30	-73.45
Petasites palmatus	2.57	0.38	0.22	-85.21	-42.11
Viola spp.	2.17	6.00	4.55	176.5	-24.17
Total percent change per site				+2582.24	-1369.00
Average percent change				+135.91	-72.05

strata were included in the assessment. If the percent change value is positive, it indicates an increase in species frequency and cover, while a negative value reflects a decrease.

Generally, there was an increase in species frequency and cover between 1985 and 1986 at both aspen sites (Tables 5 and 6). However, there was a greater increase at the treated site than the control site. At both the Treated Aspen and Control Aspen sites, the percent change was negative for the 1986-87 comparison period. The average percent change for 1986/1987 was -67.14% for the Treated Aspen site and -63.75 for the Control Aspen site, a difference of only 3.39%. This difference is not statistically significant (t-test, $p<0.1$) and may be attributable to errors in field estimates of plant cover or natural variability. The conclusion is that glyphosate applications in 1985 and 1986 do not appear to have affected the composition and abundance of understory vegetation.

The association values for the Control and Treated Burn sites are found in Tables 7 and 8 respectively. There was an increase in species frequency and cover at both sites between 1985 and 1986 but the change was greater at the Treated Burn site. Between 1986 and 1987, there was a reduction in the association value at both sites; the average percent change values were -72.05% for the Treated Burn site and -46.48% for the Control Burn site, a difference of 25.57%. This difference is statistically significant (t-test, $p<0.01$). Therefore, the herbicide treatments appear to have reduced the composition and abundance of understory vegetation at the Treated Burn site. Because of the lack of overstory trees and shrubs at this site, more glyphosate was able to reach the ground cover.

3.2.4 Symptomatology

One of the first visible symptoms of glyphosate toxicity in plants is chlorosis or yellowing of the leaves (Abu-Irmaileh and Jordan, 1978; Bingham et al., 1980; Campbell et al., 1976; Caseley and Coupland, 1985; Hull et al., 1977; Sharma and Ag, 1986; Stark, 1982; Sutton, 1978). Other symptoms include wilting, necrosis (tissue collapse followed by brown colouration), epinasty (leaf and stem deformities), delayed flowering, and terminal die-back (Bingham et al., 1980; Sharma and Ag, 1986; Stark, 1982). Individual plant species differ widely in their response to glyphosate because of such factors as interception, retention and penetration of the chemical, the timing of the application, the physiological status of the plant during and after treatment, climatic conditions, and the activity of the herbicide (Caseley and Coupland, 1985).

Generally, grass species exhibit chlorosis and necrosis while broadleaved species display chlorosis and cupping of newly emerged leaves (Sharma and Ag, 1986). Sutton (1978) found that aspen leaves developed brown spots or became dull greenish-grey. Other shrubs either lost their leaves or those that remained were curled. Highbush blueberries (Vaccinium spp. - cultivated) experienced terminal die-back, foliar damage and delayed flowering although growth was normal in subsequent years (Hodges et al., 1978). New leaves on other plants were white with green leaf-veins indicating a lack of chlorophyll (Bingham et al., 1980). Sub-lethal doses of glyphosate reduced the total growth of some treated trees and vines but normal foliage developed within two years (Stark, 1982).

Monocotyledons, such as star-flowered Solomon's-seal [Smilacina stellata (L.) Desf.], absorbed glyphosate rapidly whereas in woody species, absorption is generally slower (Sprankle et al., 1975a). In most plant species, symptoms usually became evident after two weeks (Stark, 1982). Sharma and Ag (1986) found that under field conditions, symptoms developed slowly; weeds usually wilted within five to ten days, and death occurred ten to twenty days later. Sutton (1978) noted that annual weeds showed signs of glyphosate toxicity within two to four days while most perennial weeds required seven to ten days.

Vegetation at the New Treated Aspen plot (NT) displayed typical symptoms of glyphosate toxicity. Forty-four trees were tagged: there was one maple [Acer negundo L. var. interius (Britt.) Sarg.], two spruce and 41 trembling aspen. There were no visible signs of glyphosate injury on the spruce and maple trees. Thirty-three aspen were dead (75.0% mortality), there was top die-back in four others, one displayed leaf and stem deformities, and three were healthy.

Of the 47 shrubs in the plot, 29 were rose, fifteen were downy arrowwood, and three were willow. One willow did not seem to be affected by the spray; two showed signs of epinasty. The other two species displayed symptoms ranging from chlorosis to epinasty. One arrowwood and fifteen rose bushes were dead (2.13% and 31.9% mortality respectively). The remaining arrowwood exhibited stem and leaf deformities. Only three rose bushes were healthy; four were chlorotic and seven had symptoms of epinasty.

The majority of the eighteen indicator species in the vascular and ground layers remained healthy. This was expected because the overstory would have intercepted most of the spray. Rose and raspberry displayed epinasty symptoms. Wild columbine (Aquilegia canadensis L.), palmate-leaved colt's-foot [Petasites palmatus (Ait.) Grey], dewberry (Rubus pubescens Raf.), and star-flowered Solomon's-seal [Smilacina stellata (L.) Desf.] exhibited some chlorosis, necrosis, and epinasty. The mosses and lichens appeared to be in good condition.

3.3 Bird Surveys

The population densities of the indicator bird species for the years 1985 to 1987 are summarized in Appendix B. Most of the indicator species were still present at the treated sites one year after the second application. The difference in densities between 1985 and 1986 (Figures 4 to 7) was likely caused by a change in personnel conducting the surveys. Davis (1965) states that any variation between the observers will influence results. The densities of most of the indicator species remained fairly consistent between 1986 and 1987 at both treated sites. Only one bird species, the mourning warbler [Oporornis philadelphia (Wilson)], declined noticeably at the Treated Aspen site (Figure 4). However, since a similar drop occurred at the Control Aspen site (Figure 5), the herbicide treatments cannot be implicated. Three avian species declined at the Treated Burn site (Figure 6). Only one, the Tennessee warbler [Vermivora peregrina (Wilson)], had a similar drop at the Control Burn site (Figure 7). The other two birds, the chipping

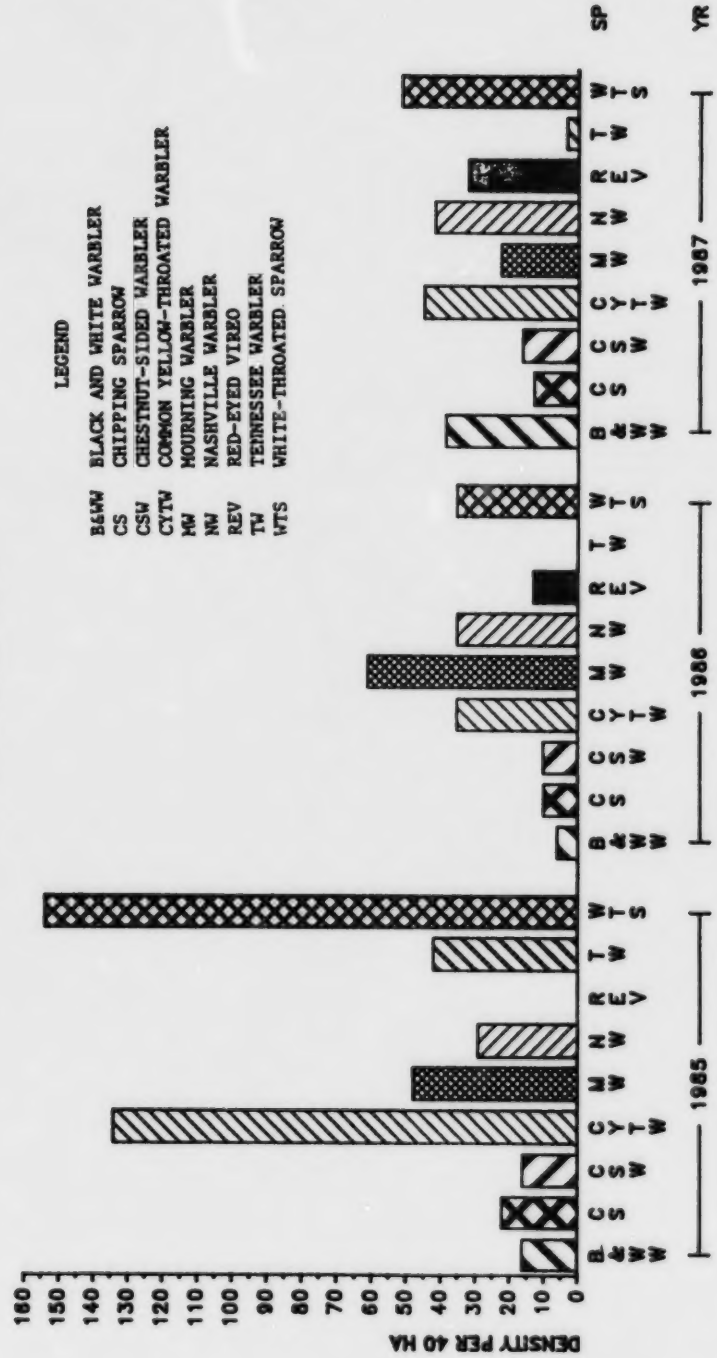


FIG. 4 : BIRD SURVEY RESULTS FOR INDICATOR SPECIES (PER 40 HA) AT SANDY RIVER WEST

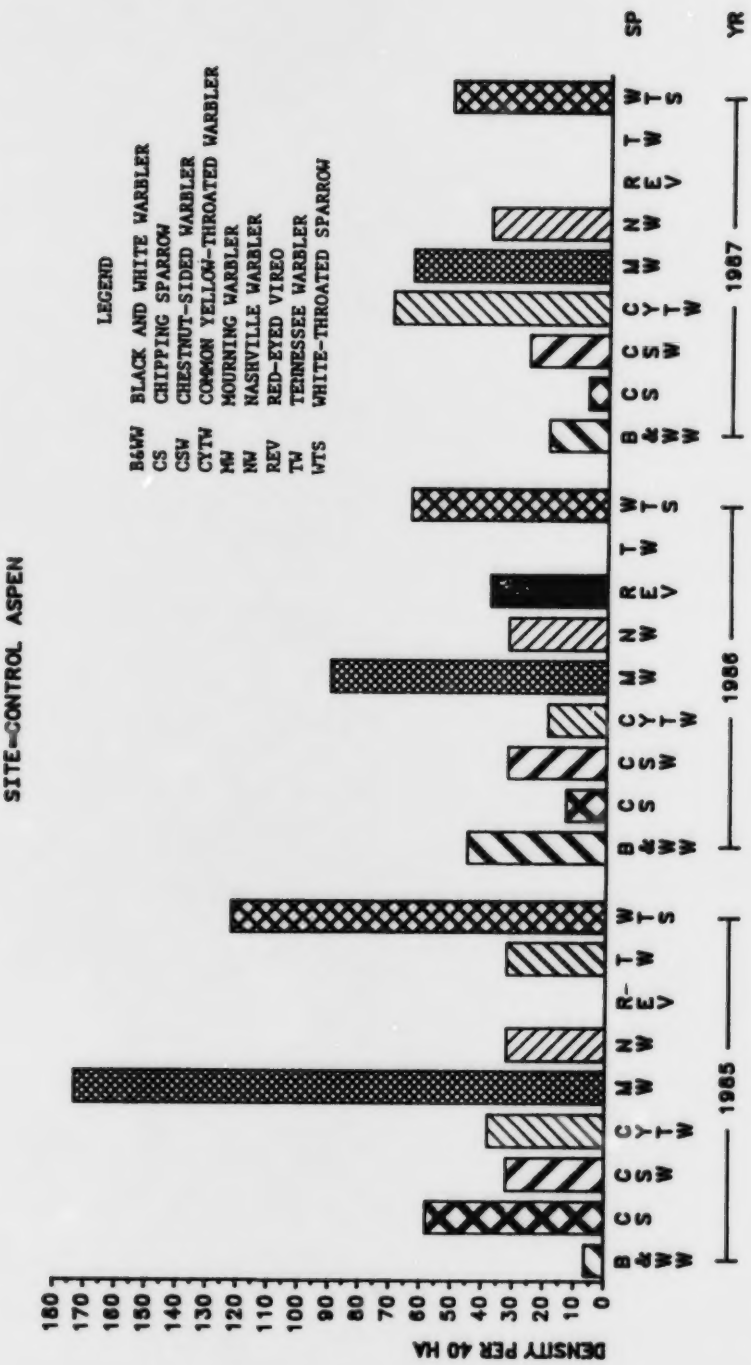


FIG. 5: BIRD SURVEY RESULTS FOR INDICATOR SPECIES (PER 40 HA) AT SANDY RIVER WEST

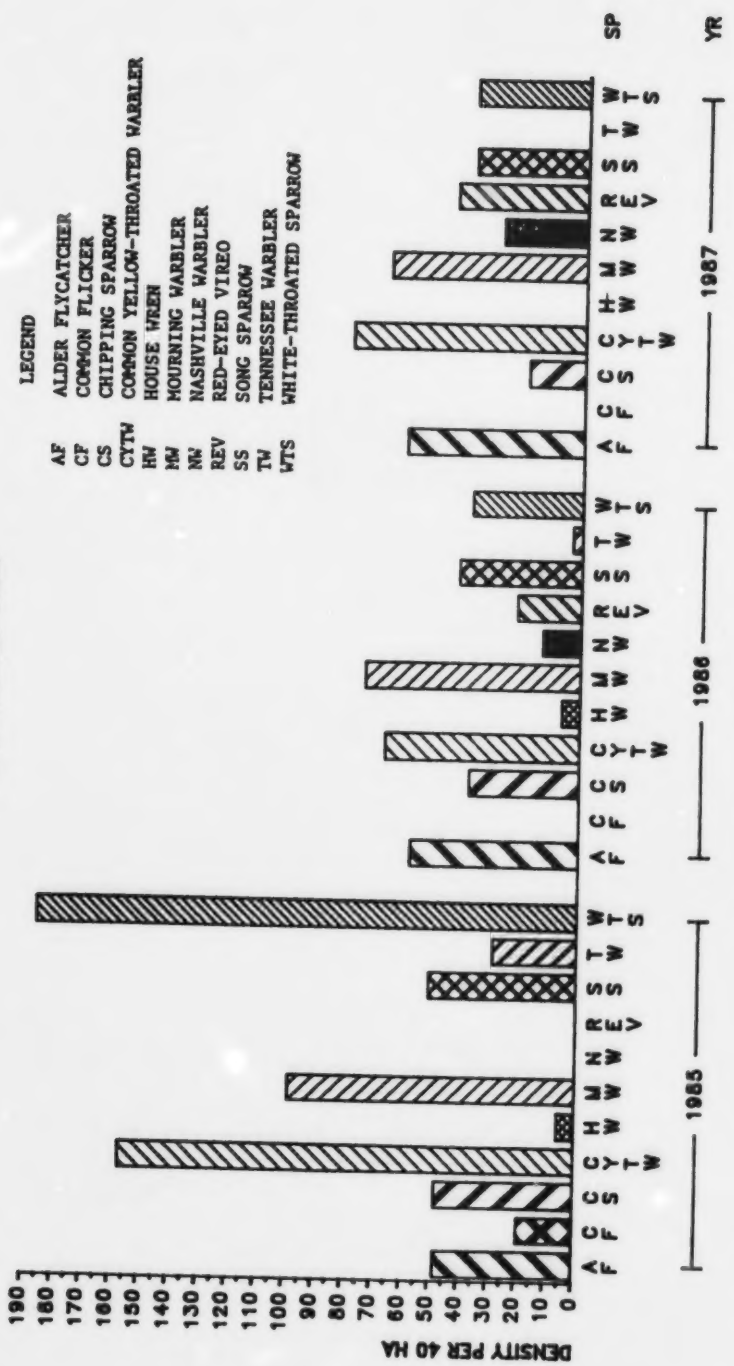


FIG. 6: BIRD SURVEY RESULTS FOR INDICATOR SPECIES (PER 40 HA) AT SANDY RIVER WEST

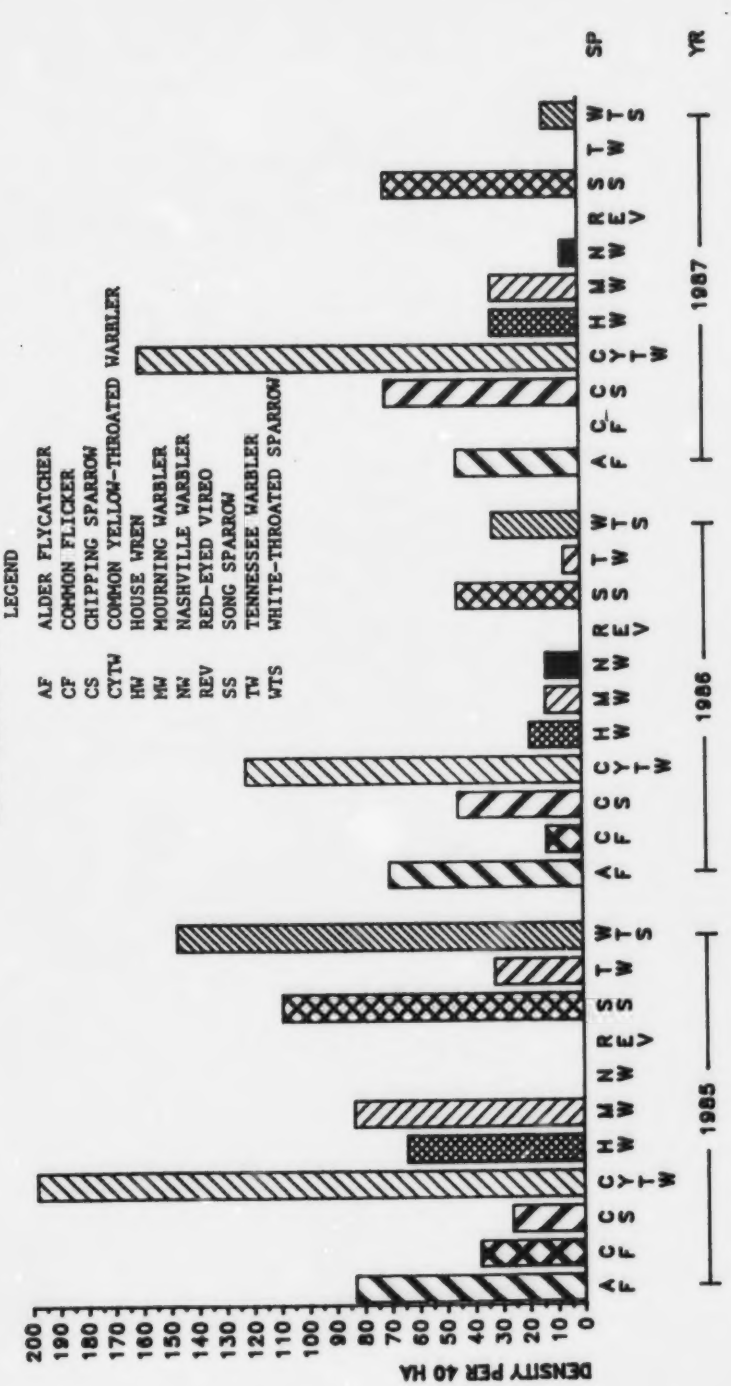


FIG. 7: BIRD SURVEY RESULTS FOR INDICATOR SPECIES (PER 40 HA) AT SANDY RIVER WEST

sparrow [Spizella passerina (Bechstein)] and the house wren [Troglodytes aedon Vieillot), experienced an increase in numbers at the control site. It is not known what factors caused the decline of these two species at the Treated Burn site.

Many environmental factors influence avian populations. The availability of food, nesting sites and territories, predation, disease, and parasites play a major role especially when bird densities are high. Other parameters that exert their influences on avian abundance include weather, natural catastrophies, habitat alterations, and man-induced disturbances. Wind direction, wind speed, and temperature are major elements that affected the extent of spring and fall migrations (Pettingill, 1985).

Because there are many factors that influence bird populations, it was difficult to determine what effect, if any, the herbicide application had on the avian densities at the sprayed sites. The uneven treatment complicated matters because strips of deciduous vegetation remained healthy. Morrison and Meslow (1984a) noted that even a retention of only a small amount of deciduous tree cover on the sprayed sites would result in bird communities similar to those on the control sites. Birds favouring deciduous habitat for foraging and nesting would increase their use of the remaining hardwood vegetation. However, Morrison and Meslow (1984a) did find that the densities of some species were lower at the sprayed site one year later and remained low until shrubs had regenerated sufficiently to provide adequate cover. Those species of birds were even sensitive to small short-term changes in habitat and preferred areas of dense

shrubs for foraging and nesting (Bent, 1953; Griscom and Sprunt, 1979; Morrison, 1982). The alder flycatcher (Empidonax alnorum Brewster) has a preference for dense thickets (Bent, 1963; Godfrey, 1986). However, its density at the Treated Burn site increased from 1985 to 1987, indicating that sufficient cover remained to satisfy the nesting and foraging requirements.

Beaver (1976) studied avian populations in treated brush fields and found that population size and species composition did not change. Within a year after treatment, patterns of avian populations were similar on both treated and untreated plots. In that study, a decrease in certain insect and seed abundance did occur. However, absence of important food sources did not produce any noticeable changes in the foraging behavior of the birds. Apparently, the birds had switched to some alternative food source and the dead shrubs still provided shelter for nesting sites.

Savidge (1978) followed up on Beaver's (1976) study and found that the total number of birds on the unsprayed plot was twice that of the sprayed plot. Her study was conducted six years after the 2,4,5-T application which had altered the vegetation composition on the treated site. Only one bird species continued to forage on the sprayed plot because its chief source of food thrived there. The other species of birds had disappeared because the vegetation required for food and/or shelter had been eliminated.

It is not surprising that the glyphosate treatment at the Sandy River West study area did not cause a decrease in bird populations or species composition. There was very little visible

effect on the vegetation and therefore the habitat was not altered sufficiently to affect the birds' use of the area.

3.4 Small Mammal Trapping

Although trapping took place in the summer and the fall, the fall trapping results are more representative of the actual population of small mammals (S. Mihok, pers. com. 1986). September's trapping results (Table 9) will be used in the discussion unless otherwise stated. Capture numbers for all trapping periods, 1985 to 1987, are recorded in Appendix C. Fluctuations in the small mammal populations are described graphically in Figures 8 to 11.

The four sites at Sandy River West were not ideal habitat for the Arctic shrew (Sorex arcticus Kerr) as shown by its sporadic capture during all trapping periods. The higher numbers trapped at both Treated Aspen and Control Burn sites disclose this mammal's preference for a moist environment such as spruce, tamarack or alder swamp (Burt and Grossenheider, 1976; Peterson, 1966). Both sites border wet areas.

The masked shrew (Sorex cinereus Kerr) population fluctuated markedly from 1985 to 1987, reaching a high in 1986, and dropping the next year. Because this population trend occurred simultaneously at all four sites, the herbicide applications cannot be implicated as the causal factor.

The population of deer mice [Peromyscus maniculatus (Wagner)] started with a high in 1985 and dropped the next year. This decline continued at the burn sites in 1987, but a slight increase occurred at

Table 9: Fall trapping results for Sandy River West, 1985-1987.

	CONTROL ASPEN			TREATED ASPEN			CONTROL BURN			TREATED BURN		
	YR			YR			YR			YR		
	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987
	CATCH	CATCH	CATCH	CATCH	CATCH	CATCH	CATCH	CATCH	CATCH	CATCH	CATCH	CATCH
	PER 1000 TRAP NIGHTS	PER 1000 TRAP NIGHTS	PER 1000 TRAP NIGHTS	PER 1000 TRAP NIGHTS	PER 1000 TRAP NIGHTS	PER 1000 TRAP NIGHTS	PER 1000 TRAP NIGHTS	PER 1000 TRAP NIGHTS	PER 1000 TRAP NIGHTS	PER 1000 TRAP NIGHTS	PER 1000 TRAP NIGHTS	PER 1000 TRAP NIGHTS
SPECIES												
ARCTIC SHREW	0.00	0.00	0.00	0.00	17.00	3.00	8.00	14.00	11.00	0.00	0.00	3.00
BOREAL REDBACK VOLE	3.00	78.00	17.00	25.00	97.00	22.00	8.00	86.00	19.00	25.00	125.00	22.00
DEER MOUSE	56.00	25.00	39.00	17.00	6.00	8.00	42.00	15.00	3.00	56.00	17.00	8.00
LEAST CHIPMUNK	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MASKED SHREW	14.00	86.00	6.00	47.00	92.00	22.00	42.00	75.00	8.00	3.00	86.00	25.00
MEADOW JUMPING MOUSE	0.00	3.00	0.00	0.00	11.00	0.00	11.00	3.00	0.00	3.00	6.00	0.00
MEADOW VOLE	0.00	0.00	17.00	0.00	3.00	28.00	0.00	3.00	42.00	0.00	0.00	11.00

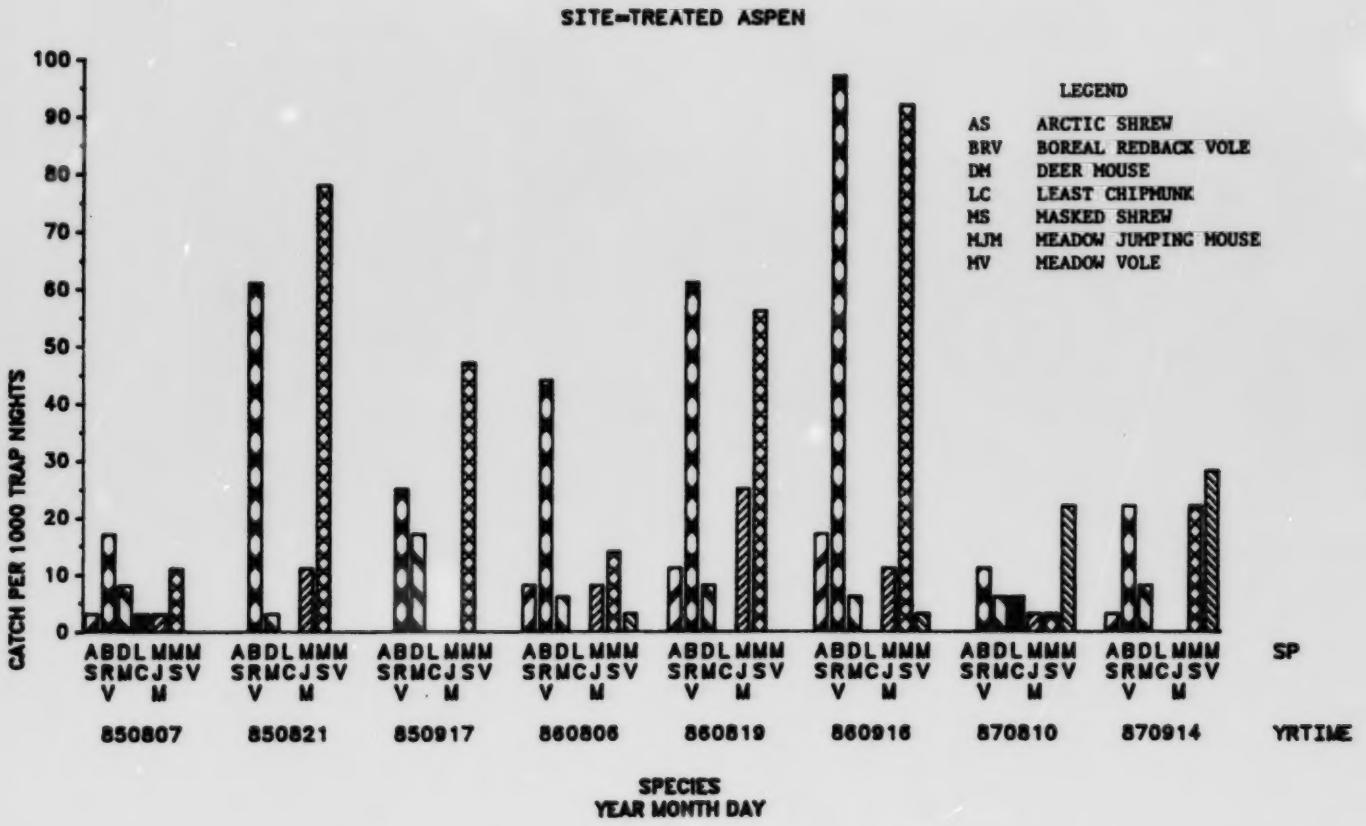


FIG. 8: TRAPPING RESULTS FOR 7 COMMON SMALL MAMMALS (PER 1000 TRAP NIGHTS) AT SANDY RIVER WEST

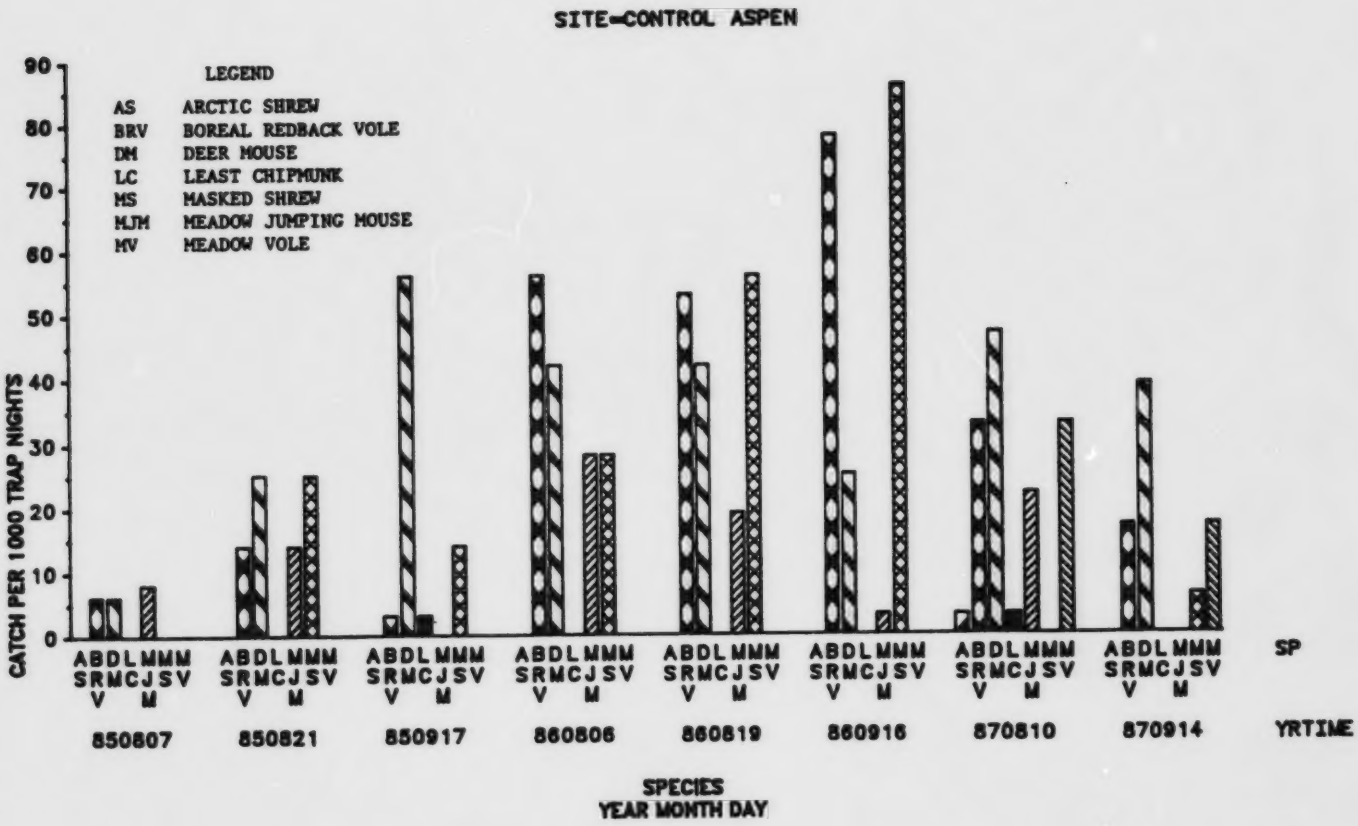


FIG.9: TRAPPING RESULTS FOR 7 COMMON SMALL MAMMALS (PER 1000 TRAP NIGHTS) AT SANDY RIVER WEST

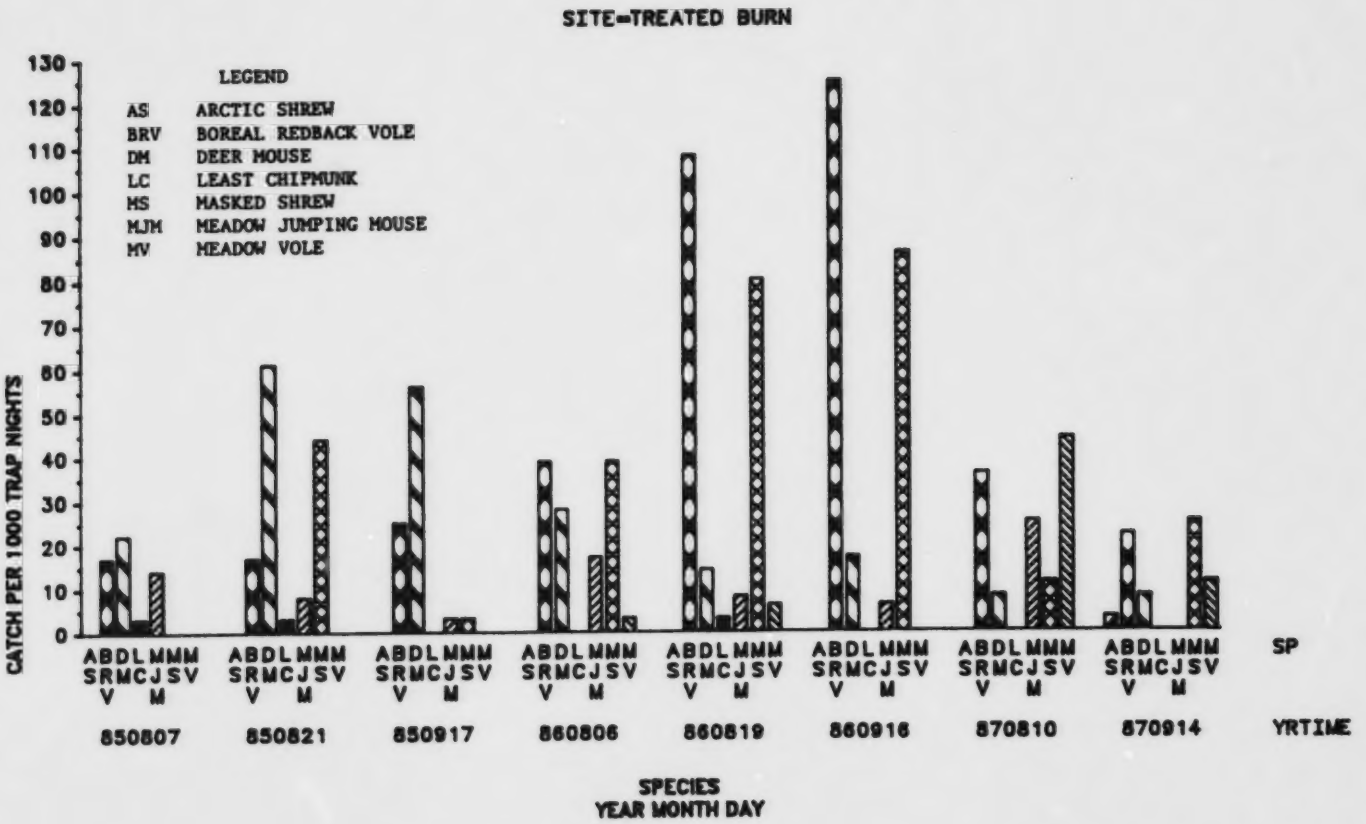


FIG.10: TRAPPING RESULTS FOR 7 COMMON SMALL MAMMALS (PER 1000 TRAP NIGHTS) AT SANDY RIVER WEST

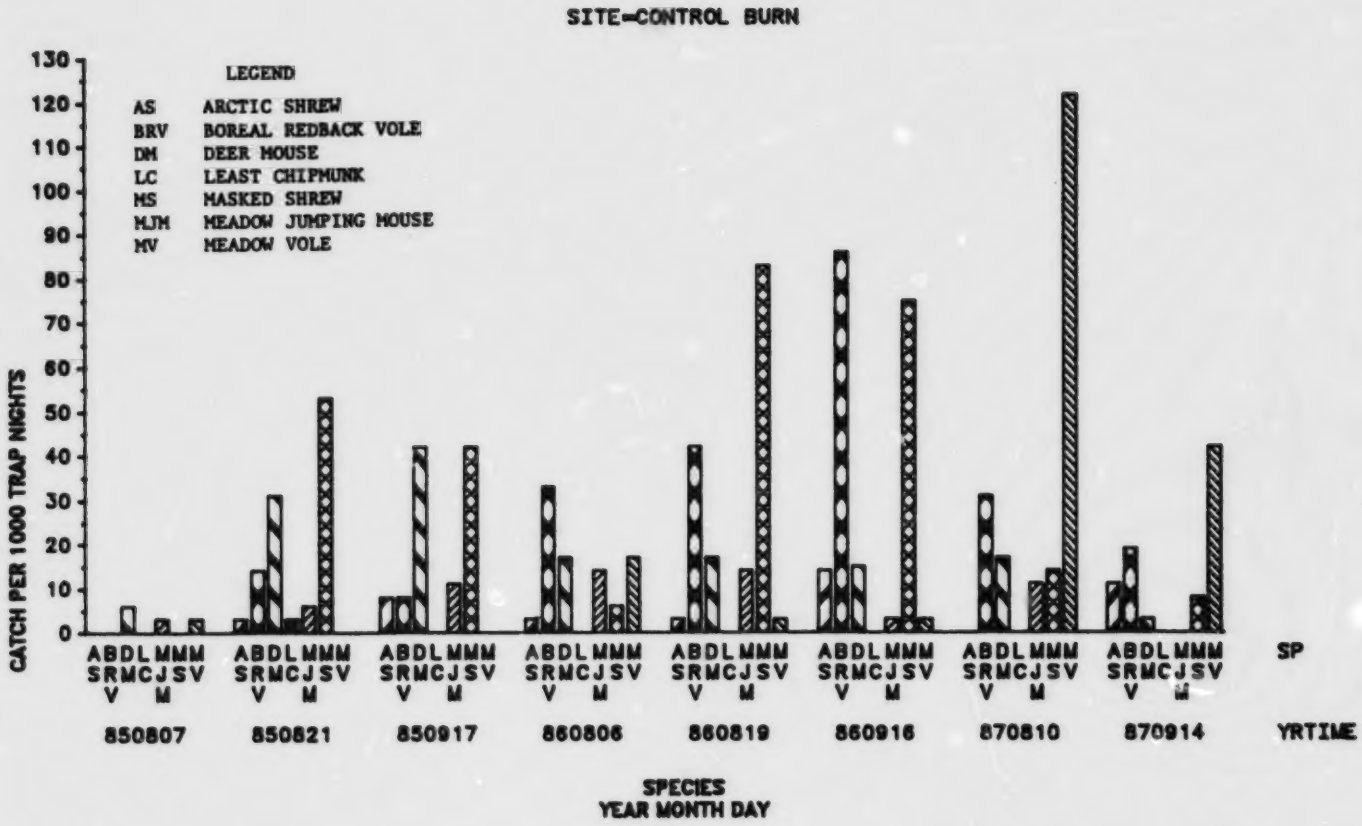


FIG.11: TRAPPING RESULTS FOR 7 COMMON SMALL MAMMALS (PER 1000 TRAP NIGHTS) AT SANDY RIVER WEST

the aspen sites. Deer mice prefer habitat with some cover and will avoid large exposed areas (Peterson, 1966). This may explain the small increase at the aspen sites and the continued drop at the burn sites in 1987.

The density of meadow voles [Microtus pennsylvanicus (Ord)] increased steadily from 1985 to 1987. Only one vole had been caught in early August of 1985. Burt and Grossenheider (1976) and Peterson (1966) report that the meadow vole population fluctuate widely with peaks occurring every three to four years. The low densities of meadow voles in 1985 may represent the low point in this natural fluctuation.

The decline of deer mice might have been the result of competition with the meadow voles. Petticrew and Saddleir (1974) discovered a weak inverse relationship between deer mice and creeping voles (M. oregoni Merriam) in their study. In the one plot with a high number of creeping voles, the deer mice population eventually vanished. Grant (1971) researched the interaction between caged populations of meadow voles and deer mice. He found that meadow voles displaced the deer mice from the grassland habitat that the voles preferred. All four sites at Sandy River West have grass as a major component in the understory.

The boreal redback vole [Clethrionomys gapperi (Vigors)] population seemed to follow a cyclic trend, too. It increased from 1985 to 1986 and then crashed the next year. This cycle occurred simultaneously at all four plots, indicating demographic factors as the cause rather than the herbicide treatments. Redback voles require

more water than other voles and deer mice and hence are more susceptible to drought (Ramirez and Hornocker, 1981). This could have been the limiting factor because the surface water available to these voles declined from 1985 to 1987. Prime habitat for redback voles is damp areas in coniferous, deciduous or mixed forests (Burt and Grossenheider, 1976; Peterson, 1966).

The density of the meadow jumping mouse [Zapus hudsonius (Zimmermann)] was low at all four plots for the three years. Apparently, this mouse prepares for hibernation as early as mid-September and becomes almost totally inactive during cold weather (Peterson, 1966). Also, the low capture rate may be a result of the rodent's spending a very small proportion of its above-ground activity foraging (Bracher et al., 1986). Burt and Grossenheider (1976) state that the population fluctuates but never becomes very high. Our results substantiate this as this mouse was present in low numbers at all four sites.

The least chipmunk [Eutamias minimus (Bachman)] was caught occasionally at the plots during the three years of trapping. However, like the meadow jumping mouse the least chipmunk was not present in sufficient numbers to determine any response to the herbicide applications.

There appears to be no indirect impact on the small mammal populations one year after the second application. However, as glyphosate is a slow-acting herbicide, the full effect on the target vegetation may not become evident until two years after spraying (Lund-Hoie, 1980). Herbicide induced changes in vegetation cover and

composition may affect the density, composition and distribution of the small mammal communities (Black and Hooven, 1974; Borrecco et al., 1979: Gashwiler, 1970; Hooven, 1973; Ramirez and Hornocker, 1981; Sullivan and Sullivan, 1982; Tevis, 1956a). The animal's response to these alterations will be determined by its habitat preference (Black and Hooven, 1974; Borrecco et al., 1972; Kirkland, 1978).

In their study of effects of Roundup on deer mice, Sullivan and Sullivan (1981) found their results encouraging because no adverse effects on reproduction, growth or survival of deer mice one year after treatment was apparent. Inconsistencies in growth rates and juvenile survival which they observed between control and experimental populations of deer mice could have been due to either the herbicide application or demographic factors.

In another study by Sullivan and Sullivan (1982), the responses of small mammal populations to changes in their habitat by Roundup was researched. Generally, no adverse effects on the distribution and abundance of the small mammal population were found one year after habitat alteration.

In a study of the effects of the herbicide, 2,4-D, on pocket gopher (Thomomys talpoides Wied-Neuwied) populations and their food habits, Keith et al., (1959) discovered an 87% reduction in the numbers of gophers one year after treatment. The gopher's diet had changed from a high-forb/low-grass content to a 50/50 forb/grass content because the habitat composition had switched from forbs to grass.

Alternatively, Savidge (1978) captured more small mammals on the sprayed plot than on the control plot six years after the herbicide 2,4,5-T was applied. She attributed the higher numbers of

yellow pine chipmunks [Eutamias amoenus (J. A. Allen)] and golden-mantled ground squirrels (Callospermophilus lateralis Merriam) to a combination of factors. Open spaces combined with an abundance of certain vegetation species produced ideal habitat for these rodents.

So far at Sandy River West, the fluctuating trends in the small mammal populations have occurred at both control and treated plots, indicating no indirect effects from the herbicide. However, if more changes in the vegetation cover and composition take place, the small mammal communities may be affected according to their individual responses to these alterations.

3.5 Ungulate Studies

3.5.1 Winter Surveys

Winter survey information is summarized in Appendix D. Only deer tracks were recorded the first winter (1985/1986). In December, snow depths ranged from 30 to 40 cm, there was no crust on the snow, and temperatures averaged -15°C. Deer activity occurred at the two aspen sites and along one edge of the Control Burn site. The east side of this burn site consists of a stand of trees that were killed by the fire but which could still provide some shelter (Davis, 1977). Deer may refrain from using the Treated Burn site because it is a large clearcut which offers little cover.

The size of an open area and the amount of available cover determines its use by deer. Depending on the habitat type, optimum size for deer utilization ranges from less than 10 ha to less than

130 ha (McGinnes, 1969; McNicol and Gilbert, 1980; Reynolds, 1962a; Reynolds, 1966). Lyon (1976) and Miller (1974) discovered that openings smaller than 16 ha were utilized more by deer. Also, when the height of the cover increased, so did the use of the area by deer (Lyon and Jensen, 1980). Drolet (1978) found that in winter the use of clearcuts dropped considerably.

By the end of January, snow depth had reached 50 cm, a crust had formed, and temperatures had dropped to -19°C. No tracks were recorded at any of the plots. Deer usually restrict their winter movement when snow depth exceeds 30 to 45 cm (Drolet, 1978; Wobeser, 1985). The formation of a crust can compound the situation by causing leg injuries, by making foraging more difficult and creating difficulties in movement (Wobeser, 1985). Under these conditions deer prefer closed-canopy woodlands which offer protection from the cold, easier footing and better snow conditions. Forested areas reduce heat loss by wind-chill and minimize snow drifts, snow depth, and crust formation (DeByle, 1984; Drolet, 1978; Wobeser, 1985). The aspen sites at Sandy River West are open-canopy woodlands which may explain why no tracks were recorded in late winter.

Both deer and moose tracks were recorded the second winter (1986/1987). The weather conditions were mild most of the winter but a blizzard in early November deposited a large amount of snow. Although snow depths ranged from 35 to 47 cm, there was no crust and deer were active at all sites in mid-November. By late winter, no deer tracks were recorded at the four sites; deep snow and crusts may have discouraged deer from using the sites.

Moose were fairly active at Sandy River West, especially at the Treated Aspen site, in December 1986. Reportedly, moose will remain and browse in an area for a considerable time (Dodds, 1960). Evidently this is what occurred at the Treated Aspen site because bedding sites and many tracks were recorded during the December 12th survey. Snow depth ranged from 41 to 54 cm but moose do not confine their movements to forested areas until snow has accumulated beyond the depth of 75 cm (Chamberlin, 1972). By the middle of February the moose had moved out of the area. Chamberlin (1972) states that moose tend to utilize different portions of their large ranges at various times during the winter.

Six surveys were completed the third winter (1987/1988). The first survey was not conducted until the middle of December because snowfall was late. Deer activity was recorded at three sites: both control sites and the Treated Burn site. At the Treated Burn site, the deer had ventured out from nearby cover to feed on red-osier dogwood. No crust, mild temperatures, and little snow permitted the deer to forage for food without expending too much energy (Mattfeld, 1974; Parker et al., 1984; Verme, 1968; Wobeser, 1985).

Temperatures dropped to below normal at the beginning of both January and February in 1988. Winter surveys conducted after these cold snaps showed reduced deer activity. Deer tracks were recorded in the aspen sites only where tree cover offered windchill protection. Snow had accumulated to a depth of 43 cm at some sites, and a crust had formed at all sites by mid-February.

No moose tracks were recorded at any plots during this winter survey period. Moose may winter in different parts of their ranges from year to year (Chamberlin, 1972).

Winter survey data indicate a random utilization of the four sites at Sandy River West. Ungulate density is low and there is limited demand on the browse species (D. Schindler, pers. com. 1986). The fact that the deer and moose still used the treated sites implies that sufficient cover and food remain one year after the second application.

3.5.2 Pellet-Group Counts

The counting of fecal pellet groups for a given area provides estimates of the actual or relative numbers of ungulates, or their days of use, for that area (Neff, 1968). This is useful in determining preferred habitat types and seasonal use patterns (Riney, 1957). However, the technique is best suited to areas of high ungulate density (Neff, 1968; Wallmo and Schoen, 1980).

Because of the low ungulate density at Sandy River West, very few pellet groups were found in the 4 m^2 sampling plots. To compensate for the low numbers, any sighting of fecal material along the transects was recorded and added to the totals from the sampling plots (Table 10). However, numbers were still too low to statistically determine usage of the areas. The presence of fecal material did indicate some use by ungulates.

Table 10: Number of ungulate pellet groups counted at Sandy River West, 1985-1987 (Numbers in brackets are pellet groups found outside the sampling plots).

	1985/1986		1986/1987		1987/1988	
Plot	Deer	Moose	Deer	Moose	Deer	Moose
Control Aspen	-	- (2)	-	- (8)	-	1
Treated Aspen	1	1	2	2	-	-
Control Burn	4 (1)	-	- (6)	- (2)	1 (1)	1
Treated Burn	-	-	-	-	2 (1)	-

Pellet groups from both species were removed from the sampling plots at the Treated Aspen site in the spring of 1986 and 1987. It is surprising that more moose pellet groups were not found at this plot in 1987 because of the extensive use by moose the previous winter. No fecal material was noticed along the transects at the Treated Aspen site in the spring of 1988 although there was deer activity during the previous winter. Only moose pellets were found at the Control Aspen plot each spring. This is not substantiated by the winter track surveys which indicated use by deer only.

No pellet groups were found along the transects at the Treated Burn site for 1985/1986 and 1986/1987. Winter track surveys for these two years substantiate this as few tracks were recorded at this plot. However, pellet groups were recorded at the Treated Burn

site the last spring (1988) in the same vicinity as the winter surveys and browse studies indicated foraging by deer. Deer pellets were found each spring at the Control Burn site at the same location as deer tracks were found in the winter. Moose fecal material was discovered along the Control Burn transects the last two springs although moose tracks were recorded only in the 1986/1987 winter surveys.

3.5.3 Browse Studies

Preferred browse by stem count was calculated by using Telfer's (1972) preference factor equation (Table 11). Risenhoover (1985) defines species preference as a function of its abundance and the net energy economics of feeding on it relative to other available forage. Although moose feed on shrubs in proportion to their availability, they tend to take more browse from stems of preferred species (Healy, 1967; Nystrom, 1980). At Sandy River West, red-osier dogwood was browsed heavily by ungulates even though it was not very abundant. White birch was the second favourite forage species. Willow, aspen, poplar and rose were consumed in varying quantities.

Browse utilization is defined as the number of stems browsed versus the number of stems unbrowsed (Milliken, 1979). At Sandy River West the degree of browsing was low. One factor was the low ungulate density. Also, ungulates do not feed uniformly over an area (Shafer, 1963). Because deer and moose are selective browsers and tend to feed heavily on a few stems, only a fraction of the available plant stems are consumed (Risenhoover, 1985; Telfer, 1972). Plant palatability to ungulates is affected by the variability in their chemical components

Table 11: Browse preference at Sandy River West, 1986-1988.

SPECIES	CONTROL ASPEN			TREATED ASPEN			CONTROL BURN			TREATED BURN		
	YEAR			YEAR			YEAR			YEAR		
	1986	1987	1988	1986	1987	1988	1986	1987	1988	1986	1987	1988
	PREFERENCE FACTOR BY STEM COUNT	PREFERENCE FACTOR BY STEM COUNT	PREFERENCE FACTOR BY STEM COUNT	PREFERENCE FACTOR BY STEM COUNT	PREFERENCE FACTOR BY STEM COUNT	PREFERENCE FACTOR BY STEM COUNT	PREFERENCE FACTOR BY STEM COUNT	PREFERENCE FACTOR BY STEM COUNT	PREFERENCE FACTOR BY STEM COUNT	PREFERENCE FACTOR BY STEM COUNT	PREFERENCE FACTOR BY STEM COUNT	PREFERENCE FACTOR BY STEM COUNT
BETULA PAPYRIFERA	0.0	3.1	0.1	10.0	5.6	0.0	1.6	3.9	0.0	0.0	.	.
CORNUS STOLONIFERA	.	.	.	11.2	12.1	9.1	.	.	.	.	0.0	4.4
POPULUS BALSAMIFERA	0.0	0.2	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0
POPULUS TREMULOIDES	1.4	0.2	0.4	0.0	0.2	0.0	0.0	0.0	0.0	1.1	0.0	0.0
ROSA ACICULARIS	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SALIX SPP.	0.9	1.4	1.8	0.0	0.2	0.0	1.4	0.4	1.5	2.7	0.0	0.0

both within and between habitats (Risenhoover, 1985). Therefore, it is not uncommon to find unbrowsed stems growing along side plants that have been heavily utilized (Risenhoover, 1985). This was a common occurrence at all four sites. In some instances shrubs adjacent to the 4 m^2 sampling plots were browsed and the same species within the plots were not.

One-way analysis of variance (ANOVA) statistics were run on the total browse available at each site. Table 12 summarizes the ANOVA results for each habitat and year. Variations in total browse between years for each site were also calculated using one-way ANOVA statistics (Table 13).

In 1988, there was a significant difference (ANOVA, $p<0.01$) between the means of the total browse available to ungulates between the two aspen sites (Table 12). Mean total available browse decreased (ANOVA, $p<0.05$) from 1987 to 1988 at the Treated Aspen site (Table 13). The Student-Newman-Keuls (SNK) test ($\alpha=0.05$) showed that mean available browse in 1988 was significantly lower than in 1986 or 1987 (indicated by underlining). This decline could be attributed to the glyphosate sprays. Connors and Gratz (unpublished) found a similar reduction in total biomass of browse species in cutovers treated with glyphosate.

There was significantly less mean total available browse (ANOVA, $p<0.05$) at the Treated Burn sites in 1986, 1987 and 1988 (Table 12). However, there was no significant change in the mean total available browse between years at the Treated Burn site (Table 13). The results in Table 12 may be ascribed to the compound effects

Table 12: One-way analysis of variance comparing means of total available browse between treatment for each habitat and each year, Sandy River West, 1986 to 1988 (d.f.=1; α=0.05).

		Treatment		
Year	Habitat	Control	Treated	F Value
1986	Aspen	29.26	26.38	0.29
	Burn	10.67	5.48	4.81*
1987	Aspen	23.98	29.73	0.93
	Burn	15.49	7.18	6.09*
1988	Aspen	30.26	15.13	8.34**
	Burn	22.04	8.53	6.86**

* $p<0.05$
** $p<0.01$

Table 13: One-way analysis of variance comparing means of total available browse between years within sites, Sandy River West, 1986 to 1988 (d.f.=2; α=0.05).

Site	1986	1987	1988	F value
Control Aspen	29.26	23.98	30.26	0.77
Treated Aspen	<u>26.38</u>	<u>29.73</u>	15.13	3.68*
Control Burn	10.67	15.49	22.04	2.58
Treated Burn	5.48	7.18	8.53	1.24

* $p<0.05$
Underlining indicates groups of means that are significantly different from others.

of the herbicide treatments and the 1984 forest fire. More browse species were recorded at the untreated site and is likely the result of the natural variation in regrowth of the areas. Studies (Habeck and Mutch, 1973; McRae, 1979; Morgan and Neuenschwander, 1984; Norum,1979; Wielgus, 1981, Zinke, 1962) on the effects of fire on the soil and postfire regeneration indicate that many factors interact together to determine the composition and frequency of the plant species appearing after a fire. Thus, the significant difference (ANOVA, $p<0.05$) in 1986 may be attributed more to the fire than to the first spray. Because glyphosate may have a two-year lag period (Malik and Vanden Born, 1986), the significant difference (ANOVA, $p<0.01$) in 1988 may be indicating an increased influence from the herbicide applications.

A two-way ANOVA statistical test was run on the availability of each individual browse species for each year, 1986 to 1988 (Table 14). In 1986, the significant differences in mean available browse between habitats and treatments and the significant interaction term may again be attributed more to the effect of the forest fire in 1984 and the variable regeneration of the vegetation than to the 1985 herbicide treatment. As was noted in the vegetation assessment after the first glyphosate application, there was no noticeable herbicidal effect.

To help clarify the data from Table 14, one-way ANOVA statistical tests were conducted on each browse species to determine possible significant changes between years at each site (Table 15). If the amount of browse decreased significantly at the treated sites,

Table 14: Two way analysis of variance comparing means of available browse of individual species each year (model: habitat x treatment), Sandy River West, 1986-1988.

		Overall F	Habitat - Means		Between Habitat	Treatment - Means		Between Treatments	Interaction
Year	Species	(d.f.=3)	Aspen	Burn	(d.f.=1)	Control	Treated	(d.f.=1)	(d.f.=1)
1986	Betula papyrifera	4.40**	8.31	1.19	8.86**	6.94	2.56	3.35	1.01
	Cornus stolonifera	2.03	4.65	0.00	2.03	0.00	4.65	2.03	2.03
	Populus balsamifera	1.12	5.71	2.07	1.45	3.52	4.26	0.06	1.85
	Populus tremuloides	12.95***	64.90	11.80	35.84***	31.29	45.41	2.53	0.47
	Rosa acicularis	6.99***	19.85	8.41	7.07**	7.38	20.88	9.84**	4.07*
	Salix spp.	11.56***	63.50	24.99	11.49***	70.66	17.83	21.63***	1.56
1987	Betula papyrifera	1.59	8.29	4.62	0.81	10.46	2.45	3.86	0.09
	Cornus stolonifera	1.63	5.39	2.64	0.46	0.00	8.03	3.96*	0.46
	Populus balsamifera	0.77	9.54	4.57	1.38	8.42	5.69	0.42	0.51
	Populus tremuloides	10.06***	69.65	16.91	24.01***	31.41	55.15	4.86*	1.31
	Rosa acicularis	7.89***	14.95	6.07	7.32	4.69	16.33	12.58***	3.78
	Salix spp.	4.02**	53.30	33.18	2.12	63.41	23.06	8.53**	1.42
1988	Betula papyrifera	1.36	13.03	4.53	2.30	12.39	5.17	1.66	0.11
	Cornus stolonifera	1.91	4.57	5.82	0.08	0.00	10.39	5.57	0.08
	Populus balsamifera	1.13	9.85	4.03	1.93	8.65	5.23	0.67	0.77
	Populus tremuloides	3.80*	47.18	23.29	6.18*	41.14	29.33	1.51	3.71
	Rosa acicularis	0.64	8.00	5.62	0.85	5.57	8.05	0.92	0.15
	Salix spp.	7.59***	53.5	48.43	0.10	12.82	87.52	22.40***	0.27

* $p<0.05$
** $p<0.01$
*** $p<0.001$

Table 15: One-way analysis of variance comparing mean available browse of individual species between years, Sandy River West, 1986 to 1988 (d.f.=2; α=0.05).

Species	Site	1986	1987	1988	F value
Betula papyrifera	Control Aspen	11.70	11.68	15.72	0.33
	Treated Aspen	4.92	4.90	10.34	0.30
	Control Burn	2.18	9.24	9.06	0.71
	Treated Burn	0.20	0.00	0.00	1.00
Cornus stolonifera	Control Aspen	0.00	0.00	0.00	-
	Treated Aspen	9.30	10.78	9.14	0.02
	Control Burn	0.00	0.00	0.00	-
	Treated Burn	0.00	5.28	11.64	2.31
Populus balsamifera	Control Aspen	3.28	9.40	9.72	1.03
	Treated Aspen	8.14	9.68	9.98	0.02
	Control Burn	3.76	7.44	7.58	1.13
	Treated Burn	0.38	1.70	0.48	1.33
Populus tremuloides	Control Aspen	54.80	51.62	62.34	0.20
	Treated Aspen	75.00	87.68	32.02	5.02**
	Control Burn	7.78	11.20	19.94	1.49
	Treated Burn	15.82	22.62	26.64	0.91
Rosa acicularis	Control Aspen	8.76	5.94	6.26	0.20
	Treated Aspen	30.94	23.96	9.74	4.38*
	Control Burn	6.00	3.44	4.88	0.36
	Treated Burn	10.82	8.70	6.36	1.07
Salix spp.	Control Aspen	97.02	65.24	87.52	1.19
	Treated Aspen	29.98	41.36	19.56	0.58
	Control Burn	44.30	61.60	90.78	1.64
	Treated Burn	5.68	4.76	6.08	0.05

* P <0.05
** P <0.01

Underlining indicates groups of means that are significantly different from others.

the glyphosate treatments may have been the causal factor. In fact Populus tremuloides Michx. and Rosa acicularis Lindl., both declined (ANOVA, $p<0.01$ and $p<0.05$, respectively) from 1986 to 1988 at the Treated Aspen site. The SNK test ($\alpha=0.05$) showed that there was significantly more aspen browse available in 1986 and 1987 (underlined) than in 1988. In the case of rose, 1987 is common to both 1986 and 1988 implying that there was a significant difference in the availability of rose between 1986 and 1988. The decline in aspen and rose likely resulted from the herbicide treatments. Kennedy and Jordan (1985) found a significant reduction in the amount of browse in glyphosate treated stands. Several other studies (Lund-Hoie, 1980; Newton and Knight, 1981; Sutton, 1978) also demonstrated that glyphosate provided good control of these woody species. In the present study, the 1987 vegetation assessment substantiates this as both species were affected by the glyphosate application.

Two-way analysis of variance statistics were run on the number of browsed stems to determine if the herbicide application had affected browse consumption by ungulates on the treated areas. There were no significant differences in the number of stems which had been browsed between habitats and/or treatments.

Sullivan and Sullivan (1979) noted in their study of food preference and consumption that black-tailed deer did not avoid eating glyphosate treated browse. They assumed that the nutrient content of the dying foliage was not greatly reduced. Kennedy and Jordan (1985) felt that, generally, herbicides used for competition control in

forestry are not harmful to wildlife. However, they agreed with Krefting and Hansen (1969) and Mueggler (1966) that herbicide treatments had to be carefully planned so that browse production would be increased.

Mueggler (1966) studied the possibility of using herbicides to selectively kill the high crowns of browse species in order to stimulate basal sprouting. He encountered difficulties in determining required doses of herbicides because of variations in plant susceptibility and the fact that the herbicides are liable to kill the whole plant rather than just the top.

Herbicides have been used to maintain forests in their early successional stages to improve wildlife habitat (Ammann, 1963; Bramble and Byrnes, 1976; Freedman and Habeck, 1984; Jenkins, 1955; Krefting and Hansen, 1969; Krefting et al., 1956; Landes, 1976; Lawrence, 1967; Mueggler, 1966). This type of habitat is characterized by a variety of plants that provide food and cover for wildlife (Lawrence, 1967).

However, in an ongoing study in Ontario (Conors and Gratz, unpublished), two growing seasons after spraying with glyphosate, treated areas were used less by moose than adjacent controls. This decrease in moose utilization is presumed to be temporary.

In their feeding study, Campbell et al. (1981) found browsing rates for black-tailed deer were lower for glyphosate treated browse. They presumed the phytotoxic effects of the herbicide may have caused this lower rate.

Studies by other researchers (Chamberlain and Goodrich, 1962; Goodrum and Reid, 1956; Lindzey, 1960) have shown that suitable wildlife habitat has been lost because of herbicide treatments. In Savidge's study (1978), she found a significant difference in deer usage between treated and untreated plots. Changes in both food availability and protective cover six years after the herbicide application resulted in poor deer habitat at the sprayed plot. Lund-Hoie (1980) was concerned that because glyphosate is a slow acting herbicide, the full deterioration of the woody vegetation would not become evident until two or more years after application. Kennedy and Jordan (1985) felt that herbaceous species (not controlled effectively by glyphosate) might prevent re-establishment of desired browse species. Extreme alterations to formerly ideal ungulate habitat could result.

This is particularly crucial on winter ranges in the north where both energy intake and expenditure are important (Wallmo and Schoen, 1980; Wickstrom et al., 1984). The ability of ungulates to survive the most severe winter conditions is influenced by how well they are nourished before the onset of such conditions, how long those conditions last, and how rapidly they are renourished after the conditions abate (Wallmo and Schoen, 1980).

Because the winter ranges are smaller and less productive than the summer ranges, any factors that further limit the availability of forage in winter can have an effect on the carrying capacity of the total range (Wallmo et al., 1977). In their preliminary findings, Kennedy and Jordan (1985) indicated that

effective applications of glyphosate (from a forestry perspective) may have the potential of reducing carrying capacity. Reductions in the total forage supply result in more rapid depletion of the best forage (Carpenter et al., 1979). Low-grade foods have low digestibility and slow passage which can cause starvation on a full stomach (Wallmo and Schoen, 1980). Thus, herbicide application may have a profound impact on an ungulate's ability to survive harsh conditions (Wickstrom et al., 1984).

However, at Sandy River West, the habitat did not appear to be appreciably altered by the two herbicide applications. There was a significant decrease (ANOVA, $p<0.05$) in mean available browse at the Treated Aspen site in 1988 but this reduction in forage did not seem to discourage the use of the area by ungulates. Vegetation which had not been affected by herbicides still remained along the edges and in numerous localized patches within the treated area. This was apparently adequate to provide cover and food requirements for ungulates such as deer and moose.

3.6 Residue Results

Glyphosate residues on the deposition monitors and in vegetation and soil samples are summarized in Table 16. Changes in the amount of glyphosate in soil and foliage samples have been plotted against time after application for the Treated Aspen (Figure 12) and Treated Burn (Figure 13) plots. The plotted glyphosate values are the average of four samples.

Table 16: Glyphosate residues on deposition monitors and in vegetation and soil samples, Sandy River West, 1986 and 1987.

		DEPOSITION		VEGETATION									SOIL					
		TREE	HERB	TREE			SHRUB			HERB			SURFACE			10 cm		30cm
		0*	0	0	32	305	0	32	305	0	32	305	0	32	305	32	305	305
Site	Rep	g/ha	g/ha	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	g/ha	g/ha	g/ha	g/ha	g/ha	g/ha
Treated Aspen	2	23.500	11.500	4.800	0.050	0.000	6.300	0.070	0.000	1.900	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	3	14.750	14.750	2.200	0.200	0.000	21.000	0.400	0.000	4.400	0.100	0.000	0.000	17.754	0.000	0.000	0.000	0.000
	4	9.000	2.250	7.600	0.020	0.000	11.000	0.300	0.000	1.500	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	5	10.500	5.500	4.800	0.150	0.000	6.600	0.080	0.000	14.000	0.570	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Treated Burn	1	.	36.000	.	.	.	27.000	0.980	0.000	28.000	0.950	0.000	3.893	11.746	0.000	0.000	0.000	0.000
	2	.	44.500	.	.	.	20.000	0.910	0.000	3.900	1.400	0.000	3.647	0.000	0.000	0.000	0.000	0.000
	4	.	52.750	.	.	.	23.000	0.920	0.000	4.800	0.130	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	5	.	96.000	.	.	.	40.000	0.760	0.000	12.000	0.810	0.000	0.000	5.790	0.000	0.000	0.000	0.000

* Days post-spray

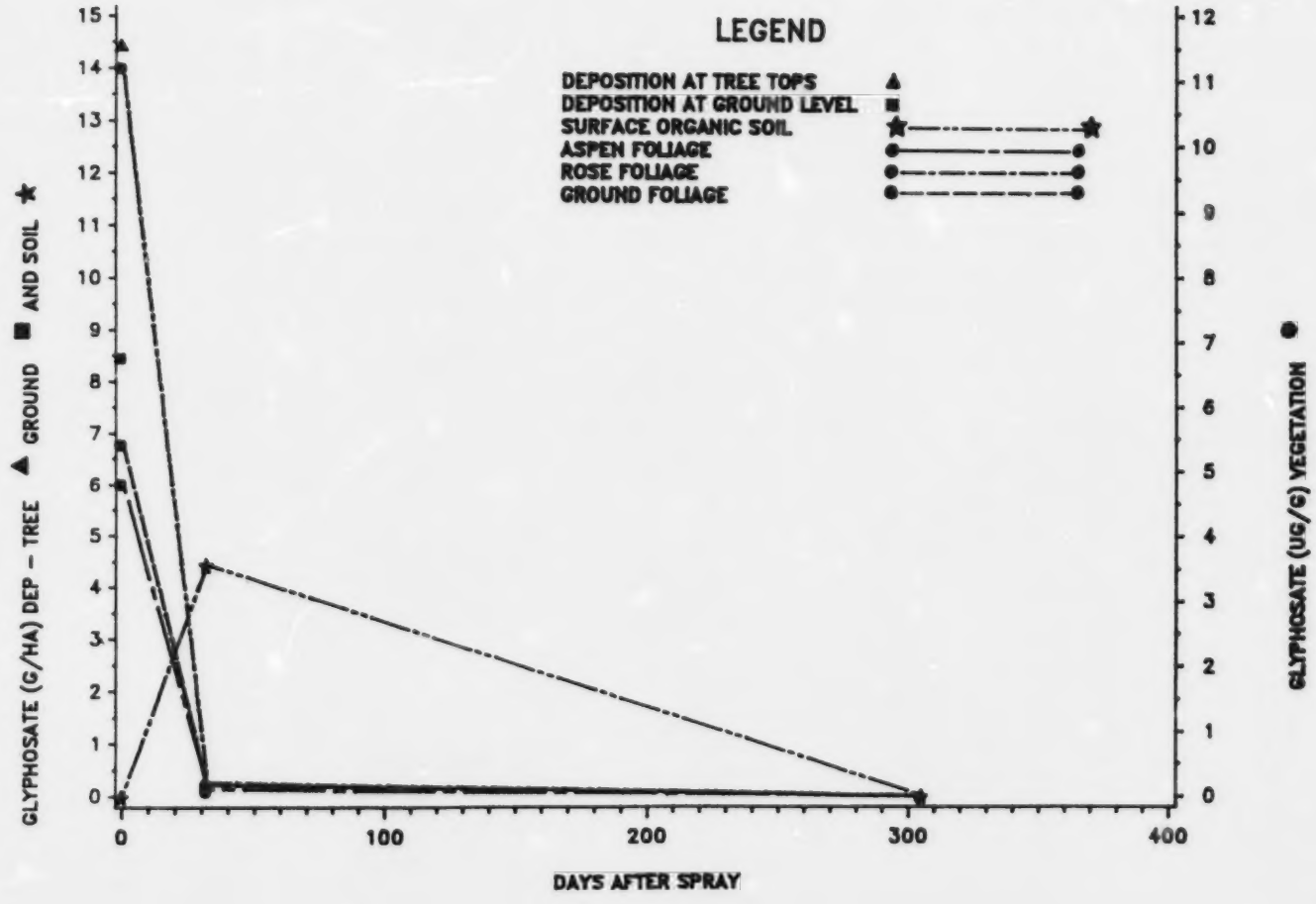


FIG.12: GLYPHOSATE RESIDUES IN SOILS, VEGETATION AND ON DEPOSITION MONITORS, TREATED ASPEN, SANDY RIVER W., 1986–1987

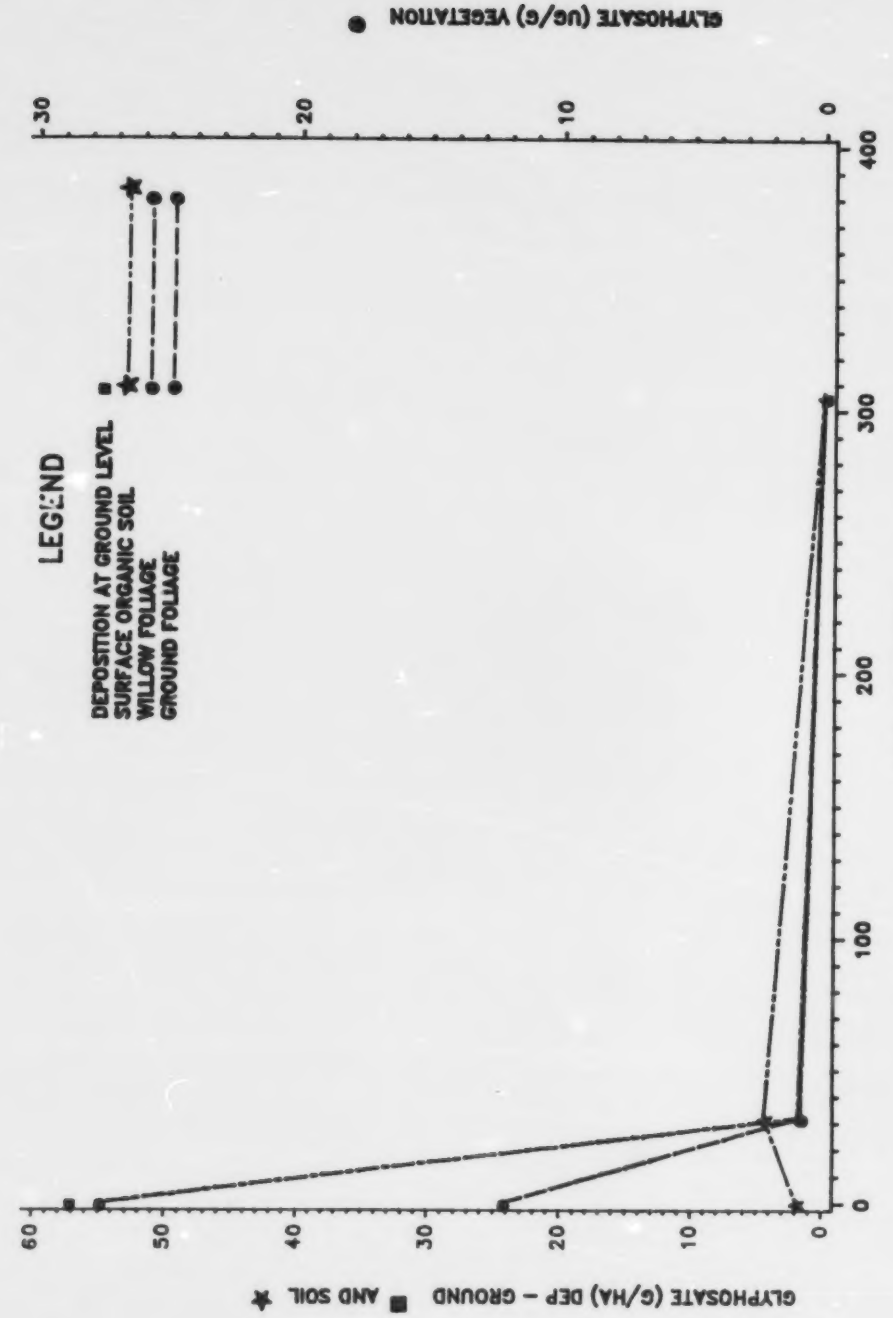


FIG.13: GLYPHOSATE RESIDUES IN SOILS, VEGETATION AND ON DEPOSITION MONITORS, TREATED BURN, SANDY RIVER W., 1986–1987

3.6.1 Deposition

At the Treated Aspen plots, the actual deposition monitored at tree level was variable (Table 16), which probably resulted from the inherent lack of precision in aerial application. Air currents within and above a canopy are dynamic and variable which can affect the distribution of spray (Cramer and Boyle, 1976). Deposition to the ground level monitors was low as expected probably because the overstory foliage would have intercepted most of the spray. At Site 3, both the upper and lower monitors had equal deposition which suggests that the lower monitor was not shielded by overstory vegetation. Subsequent examination of the canopy indicated that there was overstory vegetation at that site so air currents must have carried the spray in from an adjacent opening in the tree strata. Cramer & Boyle (1976) confirms the entry and exit of airborne material through openings which act as natural chimneys.

At the Treated Burn plot there was some variation in spray deposition between the four sites (Table 16); Site 5 had the highest value followed by sites 4, 2 and 1. Because the flight direction was east-west, the values at sites 1 and 5 should have been similar. The large difference between them may have been caused by micrometeorological factors affecting the spray pattern.

Glyphosate deposition at both treated plots was much lower than expected. The application rate was 2.5 L/ha, which converts to 890 g a.i./ha but the maximum deposition was only 96 g/ha at Site 5 of the Treated Burn plot. It appears that mylar is not a reliable monitor for glyphosate deposition. Newton et al. (1984) used mylar attached to balloons in their study and concluded that mylar sheets

were poor indicators of deposits of aerially applied glyphosate. They could find no consistent relationship between deposits on mylar sheets and foliar concentrations and did not recommend the method for quantitative evaluation of aerially applied herbicide. Results from our study support this conclusion as there was virtually no correlation between the deposits on the mylar monitors and the foliar concentrations.

No glyphosate residue was found on the mylar sheets at the control plots.

3.6.2. Foliage Residue

No glyphosate residue was found in the pre-spray foliage samples from the treated plots.

At the Treated Aspen plot, except at Site 5, the shrubs had a higher glyphosate residue than the tree or herb strata (Table 16; Figure 12). The method of sampling leaves may have had an effect on the concentration of glyphosate in the bulk sample. In the case of shrubs, entire rose bushes were sampled and a larger proportion of leaves may have been exposed to the spray. In the case of the trees, all leaves were removed from an imaginary column through the tree crown (Figure 14). Many of the lower inner leaves were probably sheltered from the spray by the higher outer leaves and their inclusion would have had a diluting effect on the residue concentration in the overall sample. Residues in the herbaceous vegetation were low, as expected, because of interception by the overstory foliage. Newton et al. (1984) also found low deposits at ground level and concluded that nearly all of the glyphosate was retained in the tree stratum.

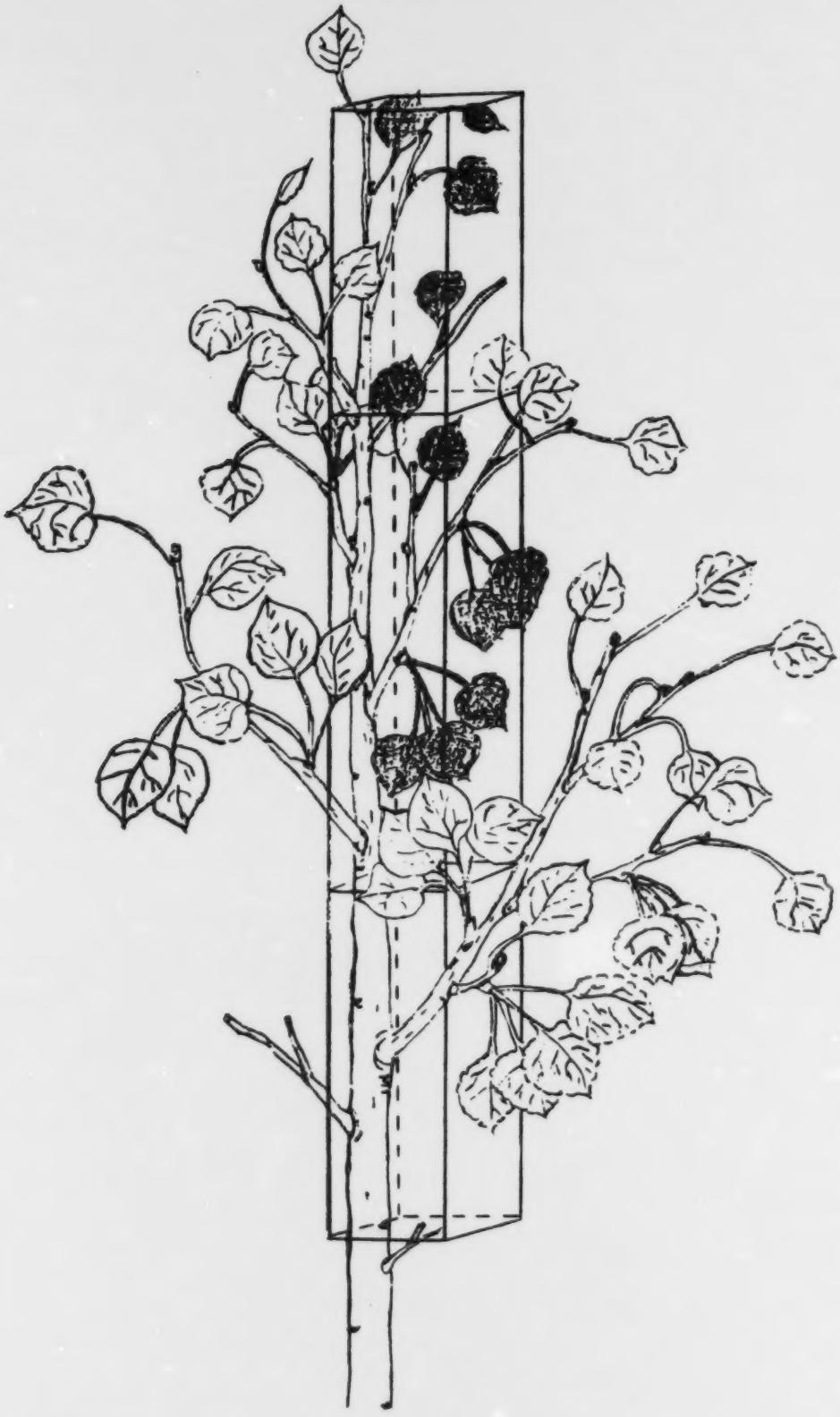


Figure 14: Diagram showing foliage sampling for aspen and willow. Shaded leaves were sampled.

Site 5 was an anomaly in that the highest residue concentration was in the herbaceous sample. A possible explanation is that air currents could have carried the spray down through an opening in the overstory canopy near this location allowing it to contact the herbs. Also, a larger proportion of the herbs sampled may have had broad leaves. Theoretically, this would reduce the ratio of sample weight to exposed surface area and would result in higher concentrations of glyphosate. Caseley and Coupland (1985) state that the development, area, angle, surface characteristics, and physical condition of the plant's leaves are of key importance in the relationship between interception, retention, and penetration of glyphosate.

Thirty-two days after the plots were sprayed, glyphosate residues in the foliage were all below 1.0 µg/g. The decline in residues in the foliage samples could have resulted from degradation, from translocation within the plants, or from wash-off by rain (Newton et al., 1984). No glyphosate residue was detected in the foliage sampled the following spring, that is, 305 days post-spray.

At the Treated Burn plot, the residue concentrations in the shrubs were relatively consistent between sites 1, 2 and 4 (Table 16; Figure 13). Site 5 was slightly higher than the other three sites. The concentrations in the herbaceous foliage were much lower as expected; Site 1 was an exception where the concentration in the herbaceous sample was the same as the shrub value. The exposure of the willow and the herbaceous plants to the spray must have been the same.

Glyphosate concentrations in the shrub and herb samples from the Treated Burn plot were generally higher than the concentrations in the foliage samples from the Treated Aspen plot. One possible reason for this is that at the Treated Aspen plot, the spray was distributed throughout three levels (tree, shrub and herb) while at the Treated Burn plot, the same amount of spray was concentrated on only two levels: shrub and herb.

Thirty-two days later, the glyphosate residues in the foliage were considerably lower and all but the herbaceous vegetation at Site 2 had values less than 1.0 µg/g. The residue values were below detection limits in the foliage sampled 305 days after the application.

The glyphosate residues in all the foliage samples from the control plots were below the detection limit.

Glyphosate enters the plant through the leaves (Sutton, 1978) and is translocated readily to areas of high meristematic activity (roots, buds, and rhyzomes) where it accumulates (Claus and Behrens, 1976; Sandberg et al., 1980; Sprankle et al., 1975a; Wyrill and Burnside, 1976). Because glyphosate is a polar, water-soluble compound, it probably penetrates the leaf's cuticle via the hydrophilic pathway (Caseley and Coupland, 1985). Once in the plant, glyphosate is converted to water-soluble salts because of the relatively high pH of plant fluids (Franz, 1985). Glyphosate absorption and translocation is affected by relative humidity, light intensity, temperature, water stress, and photosynthate translocation (Ashton and Crafts, 1981; Leonard and Crafts, 1956).

Glyphosate is ambimobile in that it exhibits both symplastic and apoplastic movements. The former involves movement within the

phloem system and the latter occurs in the xylem tissue (Bingham et al., 1980; Peterson et al., 1978).

There is a delicate balance between the movement of glyphosate within the plant and the death of the tissues. If tissue death occurs too soon, the herbicide will not have had time to translocate into other parts of the plant, for example, the roots (Caseley and Coupland, 1985; Sutton, 1978).

Glyphosate inhibits photosynthesis and growth by interrupting the shikimic acid pathway and biosynthesis of aromatic amino acids (Cole, 1985; Sharma and Ag, 1986). These aromatic amino acids are important for both protein synthesis and diverse phenolic compound formation which are necessary for plant cell life (Cole, 1985).

The absence of the shikimic acid pathway in animals is an important factor in glyphosate's low toxicity (Cole, 1985). Chronic toxicological studies revealed minimal tissue retention and rapid elimination of glyphosate residues from test animals (Monsanto Corp., 1984). Because glyphosate does not bioaccumulate in the food chain, there is little chance of human ingestion of glyphosate from the consumption of animals which may have consumed treated forest vegetation (Monsanto Corp., 1984).

Feeding tests conducted on rats, mice, quail, dogs and other animals demonstrated that glyphosate does not cause mutations, cancer, birth defects, nerve damage or adverse reproduction effects (Monsanto Corp., 1984). Doses of glyphosate as high as 300 ppm were used in those studies. In the present study at Sandy River West, residue levels in foliage samples were well below those which might induce

toxic effects in grazing animals. The highest residue concentration was 40 µg/g in the herbaceous sample from Site 5 at the Treated Burn plot which is less than one-seventh of the highest amount of glyphosate used in the feeding tests.

3.6.3 Soil Residue

Glyphosate residues were not detected in the soil at the control plots. Also, 1986 pre-spray soil samples from the treated plots had no detectable concentrations of the herbicide remaining from the 1985 application.

Two of the eight surface soil samples taken immediately after spraying in 1986 had small but detectable residues of glyphosate (Table 16). Both samples were from the Treated Burn plot (Figure 13); overstory interception probably kept the spray from reaching the soil of the Treated Aspen plot. One month later, low concentrations of residue were found in only three samples; two from the Treated Burn plot and one from the Treated Aspen plot (Figure 12). The residue concentrations found in the three 32-day post-spray samples were higher than the levels in the two immediate post-spray samples. One possible explanation for this is that rains after the spray may have washed glyphosate from the foliage onto the organic soil, resulting in the higher concentrations. No detectable glyphosate residues were found in the clay soil layer (10 cm) indicating that no downward leaching occurred. Ten months later, residues of glyphosate were not detected in either the surface organic soil or the mineral soil samples.

Glyphosate is rapidly adsorbed on soil particles (Malik and Vanden Born, 1986; Torstensson, 1985), particularly within the first hour (Hensley et al., 1978). Hensley et al. (1978) believes that two metal constituents in soil, iron and aluminum, inactivate glyphosate. Studies by Hanson and Riech (1976) indicated that glyphosate's adsorption to mineral colloids and organic matter is due primarily to formations of Fe+++ and Al+++ complexes with glyphosate. Sprankle et al. (1975b) postulated that the initial inactivation of glyphosate in soil was by reversible adsorption to clay and organic matter through the phosphonic acid moiety. Research by Torstensson (1985) substantiated this assumption.

Glyphosate is practically immobile in soils although mobility does increase slightly as the level of pH or inorganic phosphate rises (Torstensson, 1985). Leaching is very limited (Sharma and Ag, 1986).

Glyphosate may, to a minor extent, be degraded by chemical reactions, but the main route of degradation is by microbial activity (Knuuttila and Knuuttila, 1985; Quilty and Geoghegan, 1976; Sharma and Ag, 1986; Sprankle et al., 1975b; Torstensson and Aamisepp, 1977). Degradation occurs without any lag phase and under both aerobic and anaerobic conditions (Knuuttila and Knuuttila, 1985). It seems to be a co-metabolic process whereby the microorganisms do not use the herbicide for growth (Nomura and Hilton, 1977; Sprankle et al. 1975b; Torstensson and Aamisepp, 1977).

The principal degradation product of glyphosate is aminomethylphosphonic acid (AMPA) which is also biodegradable (Rueppel et al., 1977). This metabolite can accumulate in some soils; its rate

of degradation is often slower than for glyphosate because it forms stronger bonds with the soil (Comes et al., 1976; Knuuttila and Knuuttila, 1985; Nomura and Hilton, 1977). However, its degradation under favorable conditions is still rapid (Rueppel et al., 1977). End products are plant nutrients (phosphonic acid, ammonia and carbon dioxide) (Rueppel et al., 1977; Sprankle et al., 1975a).

The half-life of glyphosate ranges from a few days to several months or years depending on the soil type and the microbial activity in the soil (Torstensson, 1985). The strength of adsorption also has an effect by regulating the amount of glyphosate available for degradation (Torstensson, 1985). Factors affecting the microbial degradation of pesticides (such as Vision) in soil include pH, time, temperature, adsorption, moisture, and soil type (Khan, 1980).

Rapid inactivation of glyphosate in soil is an important characteristic of this herbicide. Torstensson (1985) concludes that there is no reason to suppose that glyphosate may cause any unexpected damage after application to the soil or other environmental components. For these reasons, glyphosate is considered to have an acceptable environmental risk factor.

4. CONCLUSIONS

Vegetation habitat for ungulates, small mammals and birds did not appear to be appreciably affected by the herbicide treatments. One year after the second application of glyphosate, most of the target and nontarget vegetation remained healthy at the Treated Aspen and Treated Burn sites. Spraying by fixed-wing aircraft at 2.5 L/ha did not provide uniform control of the trees, shrubs and understory vegetation. In some areas of the Treated Aspen site, most of the trees were killed by the glyphosate, and some of the shrubs and ground cover exhibited typical symptoms of glyphosate toxicity.

Glyphosate did not appear to have any indirect effect on the bird and small mammal populations up to one year after either the 1985 or 1986 applications. Most of the indicator bird species were still present at the treated plots. Sufficient cover remained to satisfy nesting and foraging requirements. Similar fluctuations in the small mammal populations occurred simultaneously at control and treated plots. These cyclic trends likely reflect demographic rather than herbicidal influences.

There was a significant difference (ANOVA, $p<0.01$) in mean total available browse between the two aspen sites in 1988. The mean available browse declined significantly (ANOVA, $p<0.05$) from 1986/1987 to 1988 at the Treated Aspen site. This alteration in the habitat did not appear to affect the use of the Treated Aspen site by ungulates.

Glyphosate deposition at the Treated Aspen and Treated Burn plots was much lower than expected. Mylar monitors appear to be an unreliable method for quantitative evaluation of aerially applied herbicide.

Immediate post-spray glyphosate residues in foliage samples were well below those which might cause toxic effects if consumed by birds and animals. Residue levels decrease with time and were below detection limits in foliage sampled 305 days after the application.

Glyphosate residues were found in the surface organic soil sampled immediately after and thirty days after the spray event. Glyphosate residues decreased through the fall and winter so that ten months after the application, none were detected in the surface organic soil. In addition, no detectable residues were found in the clay soil layer indicating that no downward leaching occurred.

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APPENDICES

APPENDIX A Physical characteristics of the herbaceous plants at Sandy River West, 1985-1987.

Physical characteristics of the herbaceous plants at Sandy River West, 1985 to 1987.

OBS	YR	MO	DY	SITE	STRATA	SPECIES	FREQ	RFREQ	DEN	RDEN	COV	RCOV	ASSOC
1	85	7	17	TA	2	RIBES OXYACANTHOIDES	0.5	15.15	3.3	18.33	7.55	17.02	4.02
2	85	7	17	TA	2	RIBES TRISTE	0.2	6.06	0.5	2.78	2.30	5.19	1.25
3	85	7	17	TA	2	ROSA ACICULARIS	0.9	27.27	4.3	23.89	15.35	34.61	8.12
4	85	7	17	TA	2	RUBUS IDAEUS	1.0	30.30	7.3	40.56	13.90	31.34	7.45
5	85	7	17	TA	2	SYMPHORICARPOS OCCIDENTALIS	0.7	21.21	2.6	14.44	5.25	11.84	2.97
6	85	7	17	TA	3	ACHILLEA MILLEFOLIUM	0.2	2.15	2.5	4.72	1.10	1.08	0.65
7	85	7	17	TA	3	AQUILEGIA CANADENSIS	0.1	1.08	0.3	0.57	0.55	0.54	0.32
8	85	7	17	TA	3	ASTER CILIOLATUS	0.7	7.53	3.6	6.79	5.95	5.84	3.32
9	85	7	17	TA	3	CIRSIUM SPP.	0.4	4.30	0.8	1.51	2.40	2.36	1.40
10	85	7	17	TA	3	EPILOBIUM ANGUSTIFOLIUM	0.6	6.45	0.8	1.51	2.80	2.75	1.70
11	85	7	17	TA	3	EQUISETUM SYLVATICUM	0.3	3.23	0.5	0.94	0.65	0.64	0.47
12	85	7	17	TA	3	FRAGARIA GLAUCA	0.3	3.23	4.5	8.49	3.55	3.49	1.92
13	85	7	17	TA	3	GALIUM BOREALE	0.9	9.68	19.0	35.85	9.75	9.57	5.32
14	85	7	17	TA	3	GALIUM TRIFLORUM	0.2	2.15	5.1	9.62	1.80	1.77	1.00
15	85	7	17	TA	3	GRASSES	1.0	10.75	0.0	0.00	47.60	46.74	24.30
16	85	7	17	TA	3	LATHYRUS VENOSUS	0.1	1.08	0.1	0.19	0.05	0.05	0.07
17	85	7	17	TA	3	MAIANTHEMUM CANADENSE	0.9	9.68	4.7	8.87	4.15	4.07	2.52
18	85	7	17	TA	3	MERTENSIA PANICULATA	0.5	5.38	1.9	3.58	3.95	3.88	2.22
19	85	7	17	TA	3	PETASITES PALMATUS	0.7	7.53	1.7	3.21	4.05	3.98	2.37
20	85	7	17	TA	3	PETASITES SAGITTATUS	0.1	1.08	0.1	0.19	0.05	0.05	0.07
21	85	7	17	TA	3	PYROLA ASARIFOLIA	0.4	4.30	1.8	3.40	0.70	0.69	0.55
22	85	7	17	TA	3	RUBUS PUBESCENS	0.6	6.45	1.2	2.26	5.70	5.60	3.15
23	85	7	17	TA	3	SMILACINA STELLATA	0.4	4.30	2.0	3.77	2.90	2.85	1.65
24	85	7	17	TA	3	THALICTRUM SPP.	0.5	5.38	1.3	2.45	2.95	2.90	1.72
25	85	7	17	TA	3	TRILLIUM SPP.	0.1	1.08	0.2	0.38	0.55	0.54	0.32
26	85	7	17	TA	3	VIOLA SPP.	0.3	3.23	0.9	1.70	0.65	0.64	0.47
27	85	7	17	TA	4	CALLIERGON RICHARDSONII	0.8	80.00	0.0	.	3.10	63.27	1.95
28	85	7	17	TA	4	CLADONIA SPP.	0.2	20.00	0.0	.	1.80	36.73	1.00

Physical characteristics of the herbaceous plants at Sandy River West, 1985 to 1987.

OBS	YR	MO	DY	SITE	STRATA	SPECIES	FREQ	RFREQ	DEN	RDEN	COV	RCOV	ASSOC
1	86	7	16	TA	2	DIERVILLA LONICERA	0.1	2.86	0.3	1.53	0.55	1.51	0.32
2	86	7	16	TA	2	LONICERA GLAUCESCENS	0.1	2.86	0.5	2.55	0.55	1.51	0.32
3	86	7	16	TA	2	RIBES OXYACANTHOIDES	0.3	8.57	2.3	11.73	2.85	7.84	1.57
4	86	7	16	TA	2	RIBES TRISTE	0.3	8.57	0.8	4.08	1.65	4.54	0.97
5	86	7	16	TA	2	ROSA ACICULARIS	0.9	25.71	6.1	31.12	16.85	46.35	8.87
6	86	7	16	TA	2	RUBUS IDAEUS	1.0	28.57	5.9	30.10	8.80	24.21	4.90
7	86	7	16	TA	2	SYMPHORICARPOS OCCIDENTALIS	0.7	20.00	3.6	18.37	5.05	13.89	2.87
8	86	7	16	TA	2	VACCINIUM ANGUSTIFOLIUM	0.1	2.86	0.1	0.51	0.05	0.14	0.07
9	86	7	16	TA	3	ACHILLEA MILLEFOLIUM	0.2	1.85	1.8	3.02	1.10	1.13	0.65
10	86	7	16	TA	3	AQUILEGIA CANADENSIS	0.5	4.63	1.0	1.68	1.75	1.80	1.13
11	86	7	16	TA	3	ASTER CILIOLATUS	0.8	7.41	6.2	10.39	7.80	8.02	4.30
12	86	7	16	TA	3	CIRSIUM SPP.	0.6	5.56	1.2	2.01	2.30	2.36	1.45
13	86	7	16	TA	3	EPILOBIUM ANGUSTIFOLIUM	0.5	4.63	1.0	1.68	1.75	1.80	1.13
14	86	7	16	TA	3	EQUISETUM SYLVATICUM	0.7	6.48	1.0	1.68	1.35	1.39	1.02
15	86	7	16	TA	3	FRAGARIA GLAUCA	0.4	3.70	3.5	5.86	3.40	3.49	1.90
16	86	7	16	TA	3	GALIUM BOREALE	1.0	9.26	18.6	31.16	9.10	9.35	5.05
17	86	7	16	TA	3	GALIUM TRIFLORUM	0.1	0.93	0.1	0.17	0.05	0.05	0.07
18	86	7	16	TA	3	GEUM MACROPHYLLUM	0.1	0.93	0.2	0.34	0.55	0.57	0.32
19	86	7	16	TA	3	GRASSES	1.0	9.26	0.0	0.00	39.00	40.08	20.00
20	86	7	16	TA	3	LATHYRUS OCHROLEUCUS	0.1	0.93	0.1	0.17	0.55	0.57	0.32
21	86	7	16	TA	3	LATHYRUS VENOSUS	0.3	2.78	0.7	1.17	1.15	1.18	0.72
22	86	7	16	TA	3	MAIANTHEMUM CANADENSE	0.8	7.41	7.5	12.56	4.40	4.52	2.60
23	86	7	16	TA	3	MERTENSIA PANICULATA	0.5	4.63	1.7	2.85	5.45	5.60	2.97
24	86	7	16	TA	3	MITELLA NUDA	0.1	0.93	0.2	0.34	0.55	0.57	0.32
25	86	7	16	TA	3	PETASITES PALMATUS	0.6	5.56	2.4	4.02	4.00	4.11	2.30
26	86	7	16	TA	3	PRENANTHES ALBA	0.1	0.93	0.1	0.17	0.55	0.57	0.32
27	86	7	16	TA	3	RUBUS PUBESCENS	0.7	6.48	4.6	7.71	6.25	6.42	3.47
28	86	7	16	TA	3	SMILACINA STELLATA	0.6	5.56	3.2	5.36	2.50	2.57	1.55
29	86	7	16	TA	3	SOLIDAGO CANADENSIS	0.1	0.93	0.5	0.84	1.75	1.80	0.92
30	86	7	16	TA	3	TARAXACUM OFFICINALE	0.1	0.93	0.1	0.17	0.05	0.05	0.07
31	86	7	16	TA	3	THALICTRUM SPP.	0.1	0.93	0.1	0.17	0.05	0.05	0.07
32	86	7	16	TA	3	TRIENTALIS BOREALIS	0.1	0.93	0.1	0.17	0.05	0.05	0.07
33	86	7	16	TA	3	TRILLIUM SPP.	0.1	0.93	0.2	0.34	0.55	0.57	0.32
34	86	7	16	TA	3	VIOLA SPP.	0.6	5.56	3.6	6.03	1.30	1.34	0.95
35	86	7	16	TA	4	CALLIERGON RICHARDSONII	1.0	66.67	0.0	.	7.10	63.11	4.05
36	86	7	16	TA	4	CLADONIA SPP.	0.5	33.33	0.0	.	4.15	36.89	2.32

Appendix A Cont'd

Physical characteristics of the herbaceous plants at Sandy River West, 1985 to 1987.

OBS	YR	MO	DY	SITE	STRATA	SPECIES	FREQ	RFREQ	DEN	RDEN	COV	RCOV	ASSOC
1	87	7	9	TA	1	AMELANCHIER ALNIFOLIA	0.1	100.00	0.1	100.00	0.05	100.00	0.07
2	87	7	9	TA	2	DIERVILLA LONICERA	0.1	2.63	0.4	2.07	0.05	0.33	0.07
3	87	7	9	TA	2	LONICERA GLAUCESCENS	0.1	2.63	0.1	0.52	0.55	3.67	0.32
4	87	7	9	TA	2	RIBES OXYACANTHOIDES	0.3	7.89	2.9	15.03	1.15	7.67	0.72
5	87	7	9	TA	2	RIBES TRISTE	0.4	10.53	1.2	6.22	0.70	4.67	0.55
6	87	7	9	TA	2	ROSA ACICULARIS	1.0	26.32	6.4	33.16	9.60	64.00	5.30
7	87	7	9	TA	2	RUBUS IDAEUS	1.0	26.32	4.0	20.73	2.00	13.33	1.50
8	87	7	9	TA	2	SYMPHORICARPOS OCCIDENTALIS	0.7	18.42	4.1	21.24	0.85	5.67	0.77
9	87	7	9	TA	2	VACCINIUM ANGUSTIFOLIUM	0.1	2.63	0.1	0.52	0.05	0.33	0.07
10	87	7	9	TA	2	VIBURNUM RAFINESQUIANUM	0.1	2.63	0.1	0.52	0.05	0.33	0.07
11	87	7	9	TA	3	ACHILLEA MILLEFOLIUM	0.2	1.87	1.6	1.95	0.10	0.60	0.15
12	87	7	9	TA	3	AQUILEGIA CANADENSIS	0.2	1.87	0.3	0.37	0.10	0.60	0.15
13	87	7	9	TA	3	ASTER CILIOLATUS	0.8	7.48	10.0	12.18	2.40	14.50	1.60
14	87	7	9	TA	3	ASTER UMBELLATUS	0.1	0.93	0.1	0.12	0.05	0.30	0.07
15	87	7	9	TA	3	CIRSIUM SPP.	0.4	3.74	0.6	0.73	0.20	1.21	0.30
16	87	7	9	TA	3	EPILOBIUM ANGUSTIFOLIUM	0.5	4.67	1.1	1.34	1.25	7.55	0.88
17	87	7	9	TA	3	EQUISETUM SYLVATICUM	0.5	4.67	0.8	0.97	0.25	1.51	0.38
18	87	7	9	TA	3	FRAGARIA GLAUCA	0.6	5.61	4.6	5.60	1.30	7.85	0.95
19	87	7	9	TA	3	GALIUM BOREALE	1.0	9.35	23.0	28.01	1.50	9.06	1.25
20	87	7	9	TA	3	GALIUM TRIFLORUM	0.1	0.93	0.3	0.37	0.05	0.30	0.07
21	87	7	9	TA	3	GEUM MACROPHYLLUM	0.2	1.87	0.6	0.73	0.10	0.60	0.15
22	87	7	9	TA	3	GRASSES	1.0	9.35	0.0	0.00	4.20	25.38	2.60
23	87	7	9	TA	3	LATHYRUS OCHROLEUCUS	0.1	0.93	0.1	0.12	0.05	0.30	0.07
24	87	7	9	TA	3	LATHYRUS VENOSUS	0.3	2.80	0.3	0.37	0.15	0.91	0.22
25	87	7	9	TA	3	LYSIMACHIA CILIATA	0.2	1.87	0.3	0.37	0.10	0.60	0.15
26	87	7	9	TA	3	MAIANTHEMUM CANADENSE	0.9	8.41	12.9	15.71	0.45	2.72	0.67
27	87	7	9	TA	3	MERTENSIA PANICULATA	0.3	2.80	0.8	0.97	0.15	0.91	0.22
28	87	7	9	TA	3	PETASITES PALMATUS	0.7	6.54	3.3	4.02	0.85	5.14	0.77
29	87	7	9	TA	3	PRENANTHES ALBA	0.1	0.93	0.2	0.24	0.05	0.30	0.07
30	87	7	9	TA	3	RUBUS PUBESCENS	0.8	7.48	10.4	12.67	1.40	8.46	1.10
31	87	7	9	TA	3	SMILACINA STELLATA	0.4	3.74	2.8	3.41	0.20	1.21	0.30
32	87	7	9	TA	3	SOLIDAGO CANADENSIS	0.1	0.93	0.6	0.73	0.55	3.32	0.32
33	87	7	9	TA	3	SOLIDAGO SPP.	0.1	0.93	0.1	0.12	0.05	0.30	0.07
34	87	7	9	TA	3	TARAXACUM OFFICINALE	0.2	1.87	0.3	0.37	0.10	0.60	0.15
35	87	7	9	TA	3	THALICTRUM SPP.	0.1	0.93	0.4	0.49	0.05	0.30	0.07
36	87	7	9	TA	3	TRILLIUM SPP.	0.1	0.93	0.1	0.12	0.05	0.30	0.07
37	87	7	9	TA	3	VIOLA SPP.	0.7	6.54	6.5	7.92	0.85	5.14	0.77
38	87	7	9	TA	4	CALLIERGON RICHARDSONII	1.0	76.92	0.0	.	1.50	69.77	1.25
39	87	7	9	TA	4	CLADONIA SPP.	0.3	23.08	0.0	.	0.65	30.23	0.47

Appendix A Cont'd

Physical characteristcs of the herbaceous plants at Sandy River West, 1985 to 1987.

OBS	YR	MO	DY	SITE	STRATA	SPECIES	FREQ	RFREQ	DEN	RDEN	COV	RCOV	ASSOC
1	85	7	15	CA	1	AMELANCHIER ALNIFOLIA	0.1	25.00	0.1	25.00	0.55	45.83	0.32
2	85	7	15	CA	1	BETULA PAPYRIFERA	0.1	25.00	0.1	25.00	0.55	45.83	0.32
3	85	7	15	CA	1	POPULUS TREMULOIDES	0.2	50.00	0.2	50.00	0.10	8.33	0.15
4	85	7	15	CA	2	CORYLUS CORNUTA	0.1	3.57	0.3	2.42	0.55	1.56	0.32
5	85	7	15	CA	2	RIBES OXYACANTHOIDES	0.6	21.43	2.0	16.13	5.20	14.77	2.90
6	85	7	15	CA	2	ROSA ACICULARIS	0.9	32.14	4.5	36.29	20.05	56.96	10.47
7	85	7	15	CA	2	RUBUS IDAEUS	0.9	32.14	3.6	29.03	7.05	20.03	3.97
8	85	7	15	CA	2	SYMPHORICARPOS OCCIDENTALIS	0.1	3.57	1.5	12.10	1.75	4.97	0.92
9	85	7	15	CA	2	VIBURNUM EDULE	0.2	7.14	0.5	4.03	0.60	1.70	0.40
10	85	7	15	CA	3	AQUILEGIA CANADENSIS	0.5	3.52	1.7	1.40	1.25	0.93	0.88
11	85	7	15	CA	3	ARALIA NUDICAULIS	0.7	4.93	5.0	4.11	15.05	11.20	7.87
12	85	7	15	CA	3	ASTER CILIOLATUS	0.8	5.63	12.9	10.60	11.90	8.85	6.35
13	85	7	15	CA	3	CIRSIUM SPP.	0.8	5.63	3.9	3.20	6.30	4.69	3.55
14	85	7	15	CA	3	CORNUS CANADENSIS	0.6	4.23	6.4	5.26	6.40	4.76	3.50
15	85	7	15	CA	3	DRYOPTERIS DISJUNCTA	0.2	1.41	2.5	2.05	1.80	1.34	1.00
16	85	7	15	CA	3	EPILOBIUM ANGUSTIFOLIUM	0.9	6.34	4.7	3.86	10.45	7.78	5.67
17	85	7	15	CA	3	EQUISETUM SYLVATICUM	1.0	7.04	5.8	4.77	6.90	5.13	3.95
18	85	7	15	CA	3	FRAGARIA GLAUCA	1.0	7.04	28.4	23.34	14.70	10.94	7.85
19	85	7	15	CA	3	GALIUM BOREALE	0.9	6.34	20.0	16.43	10.45	7.78	5.67
20	85	7	15	CA	3	GALIUM TRIFLORUM	0.2	1.41	0.4	0.33	0.10	0.07	0.15
21	85	7	15	CA	3	GEUM MACROPHYLLUM	0.4	2.82	0.6	0.49	0.70	0.52	0.55
22	85	7	15	CA	3	GRASSES	1.0	7.04	0.0	0.00	23.60	17.56	12.30
23	85	7	15	CA	3	LATHYRUS VENOSUS	0.7	4.93	1.5	1.23	0.85	0.63	0.77
24	85	7	15	CA	3	MAIANTHEMUM CANADENSE	0.7	4.93	9.7	7.97	7.45	5.54	4.07
25	85	7	15	CA	3	MERTENSIA PANICULATA	0.6	4.23	3.9	3.20	3.30	2.46	1.95
26	85	7	15	CA	3	MITELLA NUDA	0.4	2.82	7.0	5.75	1.70	1.26	1.05
27	85	7	15	CA	3	PETASITES PALMATUS	0.6	4.23	1.5	1.23	2.00	1.49	1.30
28	85	7	15	CA	3	RUBUS PUBESCENS	0.3	2.11	0.9	0.74	1.65	1.23	0.97
29	85	7	15	CA	3	SMILACINA STELLATA	0.3	2.11	1.4	1.15	2.35	1.75	1.32
30	85	7	15	CA	3	TARAXACUM OFFICINALE	0.7	4.93	1.1	0.90	3.05	2.27	1.87
31	85	7	15	CA	3	THALICTRUM VENULOSUM	0.1	0.70	0.2	0.16	0.05	0.04	0.07
32	85	7	15	CA	3	TRIENTALIS BOREALIS	0.1	0.70	0.4	0.33	0.55	0.41	0.32
33	85	7	15	CA	3	VIOLA SPP.	0.7	4.93	1.8	1.48	1.85	1.38	1.27
34	85	7	15	CA	4	CALLIERGON RICHARDSONII	0.7	100.00	0.0	.	3.05	100.00	1.87

Appendix A Cont'd

Physical characteristics of the herbaceous plants at Sandy River West, 1985 to 1987.

OBS	YR	MO	DY	SITE	STRATA	SPECIES	FREQ	RFREQ	DEN	RDEN	COV	RCOV	ASSOC
1	86	7	15	CA	1	AMELANCHIER ALNIFOLIA	0.1	33.33	0.3	30.00	3.75	30.61	1.92
2	86	7	15	CA	1	BETULA PAPYRIFERA	0.1	33.33	0.4	40.00	1.75	14.29	0.92
3	86	7	15	CA	1	POPULUS TREMULOIDES	0.1	33.33	0.3	30.00	6.75	55.10	3.42
4	86	7	15	CA	2	CORYLUS CORNUTA	0.1	2.70	0.8	5.16	1.75	3.56	0.92
5	86	7	15	CA	2	RHAMNUS ALNIFOLIA	0.1	4.00	0.1	0.79	0.05	0.11	0.07
6	86	7	15	CA	2	RIBES GLANDULOSUM	0.4	2.40	1.1	0.80	1.70	1.14	1.05
7	86	7	15	CA	2	RIBES OXYACANTHOIDES	0.8	4.79	1.8	1.31	2.60	1.74	1.70
8	86	7	15	CA	2	ROSA ACICULARIS	0.9	36.00	5.0	39.68	31.05	69.23	15.97
9	86	7	15	CA	2	RUBUS IDAEUS	0.8	32.00	2.9	23.02	4.60	10.26	2.70
10	86	7	15	CA	2	SYMPHORICARPOS OCCIDENTALIS	0.1	4.00	1.5	11.90	1.75	3.90	0.92
11	86	7	15	CA	2	VIBURNUM EDULE	0.5	20.00	2.3	18.25	5.65	12.60	3.07
12	86	7	15	CA	3	ACTAEA RUBRA	0.1	0.65	0.1	0.07	0.05	0.03	0.07
13	86	7	15	CA	3	AQUILEGIA CANADENSIS	0.6	3.59	2.7	1.96	3.00	2.01	1.80
14	86	7	15	CA	3	ARALIA NUDICAULIS	0.9	5.39	7.5	5.45	16.15	10.84	8.52
15	86	7	15	CA	3	ASTER CILIOLATUS	1.0	5.99	25.9	18.81	26.10	17.51	13.55
16	86	7	15	CA	3	CIRSIUM SPP.	1.0	5.99	2.8	2.03	2.50	1.68	1.75
17	86	7	15	CA	3	CORNUS CANADENSIS	0.6	3.59	5.4	3.92	4.00	2.68	2.30
18	86	7	15	CA	3	DRYOPTERIS DISJUNCTA	0.3	1.80	3.2	2.32	2.35	1.58	1.32
19	86	7	15	CA	3	EPILOBIUM ANGUSTIFOLIUM	0.9	5.39	3.3	2.40	7.05	4.73	3.97
20	86	7	15	CA	3	EQUISETUM SYLVATICUM	1.0	5.99	5.4	3.92	6.90	4.63	3.95
21	86	7	15	CA	3	FRAGARIA GLAUCA	1.0	5.99	18.6	13.51	11.00	7.38	6.00
22	86	7	15	CA	3	GALIUM BOREALE	1.0	5.99	16.0	11.62	9.60	6.44	5.30
23	86	7	15	CA	3	GALIUM TRIFLORUM	0.1	0.60	0.1	0.07	0.05	0.03	0.07
24	86	7	15	CA	3	GEUM MACROPHYLLUM	0.4	2.40	1.3	0.94	1.70	1.14	1.05
25	86	7	15	CA	3	GRASSES	1.0	5.99	0.0	0.00	33.60	22.54	17.30
26	86	7	15	CA	3	LATHYRUS VENOSUS	0.7	4.19	2.4	1.74	1.85	1.24	1.27
27	86	7	15	CA	3	LYSIMACHIA CILIATA	0.2	1.20	0.2	0.15	0.10	0.07	0.15
28	86	7	15	CA	3	MAIANTHEMUM CANADENSE	0.7	4.19	8.3	6.03	2.35	1.58	1.52
29	86	7	15	CA	3	MERTENSIA PANICULATA	0.6	3.59	5.0	3.63	6.00	4.03	3.30
30	86	7	15	CA	3	MITELLA NUDA	0.7	4.19	14.2	10.31	1.35	0.91	1.02
31	86	7	15	CA	3	PETASITES PALMATUS	0.4	2.40	1.4	1.02	1.20	0.81	0.80
32	86	7	15	CA	3	RUBUS PUBESCENS	0.4	2.40	1.5	1.09	1.20	0.81	0.80
33	86	7	15	CA	3	SMILACINA STELLATA	0.1	0.60	0.5	0.36	0.55	0.37	0.32
34	86	7	15	CA	3	SONCHUS ARVENSIS	0.1	0.60	0.5	0.36	0.55	0.37	0.32
35	86	7	15	CA	3	TARAXACUM OFFICINALE	0.5	2.99	2.1	1.53	4.45	2.99	2.47
36	86	7	15	CA	3	THALICTRUM VENULOSUM	0.2	1.20	0.6	0.44	0.10	0.07	0.15
37	86	7	15	CA	3	TRIENTALIS BOREALIS	0.1	0.60	0.5	0.36	0.05	0.03	0.07
38	86	7	15	CA	3	VIOLA SPP.	0.9	5.39	5.3	3.85	0.95	0.64	0.92
39	86	7	15	CA	4	CALLIERGON RICHARDSONII	1.0	83.33	0.0	.	4.20	97.67	2.60
40	86	7	15	CA	4	PELTIGERA SPP	0.1	8.33	0.0	.	0.05	1.16	0.07
41	86	7	15	CA	4	POLYTRICHUM COMMUNE	0.1	8.33	0.0	.	0.05	1.16	0.07

Physical characteristics of the herbaceous plants at Sandy River West, 1985 to 1987.

OBS	YR	MO	DY	SITE	STRATA	SPECIES	FREQ	RFREQ	DEN	RDEN	COV	RCOV	ASSOC
1	87	7	8	CA	1	AMELANCHIER ALNIFOLIA	0.1	25.00	0.2	33.33	0.55	22.92	0.32
2	87	7	8	CA	1	BETULA PAPYRIFERA	0.1	25.00	0.2	33.33	1.75	72.92	0.92
3	87	7	8	CA	1	POPULUS TREMULOIDES	0.2	50.00	0.2	33.33	0.10	4.17	0.15
4	87	7	8	CA	2	CORYLUS CORNUTA	0.1	2.70	0.5	3.23	1.75	5.62	0.92
5	87	7	8	CA	2	RHAMNUS ALNIFOLIA	0.1	2.70	0.1	0.65	0.05	0.16	0.07
6	87	7	8	CA	2	RIBES GLANDULOSUM	0.4	10.81	1.1	7.10	0.70	2.25	0.55
7	87	7	8	CA	2	RIBES OXYACANTHOIDES	0.6	16.22	2.4	15.48	0.80	2.57	0.70
8	87	7	8	CA	2	RIBES TRISTE	0.3	8.11	0.6	3.87	0.65	2.09	0.47
9	87	7	8	CA	2	ROSA ACICULARIS	0.9	24.32	6.0	38.71	23.35	74.96	12.12
10	87	7	8	CA	2	RUBUS IDAEUS	0.8	21.62	1.8	11.61	0.90	2.89	0.85
11	87	7	8	CA	2	SYMPHORICARPOS OCCIDENTALIS	0.2	5.41	1.0	6.45	0.60	1.93	0.40
12	87	7	8	CA	2	VIBURNUM EDULE	0.3	8.11	2.0	12.90	2.35	7.54	1.32
13	87	7	8	CA	3	ACTAEA RUBRA	0.1	0.57	0.1	0.06	0.05	0.10	0.07
14	87	7	8	CA	3	AQUILEGIA CANADENSIS	0.5	2.86	1.5	0.96	0.75	1.45	0.63
15	87	7	8	CA	3	ARALIA NUDICAULIS	1.0	5.71	10.6	6.80	12.50	24.20	6.75
16	87	7	8	CA	3	ASTER CILIOLATUS	1.0	5.71	32.8	21.05	20.00	38.72	10.50
17	87	7	8	CA	3	CIRSIUM ARVENSE	0.3	1.71	0.3	0.19	0.15	0.29	0.22
18	87	7	8	CA	3	CIRSIUM SPP.	0.8	4.57	1.2	0.77	0.40	0.77	0.60
19	87	7	8	CA	3	CORNUS CANADENSIS	0.7	4.00	9.7	6.23	0.35	0.68	0.52
20	87	7	8	CA	3	DRYOPTERIS DISJUNCTA	0.3	1.71	3.1	1.99	0.65	1.26	0.47
21	87	7	8	CA	3	EPILOBIUM ANGUSTIFOLIUM	0.9	5.14	3.7	2.37	1.95	3.78	1.42
22	87	7	8	CA	3	EQUISETUM SYLVATICUM	1.0	5.71	4.7	3.02	1.00	1.94	1.00
23	87	7	8	CA	3	FRAGARIA GLAUCA	1.0	5.71	25.0	16.05	6.90	13.36	3.95
24	87	7	8	CA	3	GALIUM BOREALE	1.0	5.71	21.2	13.61	1.00	1.94	1.00
25	87	7	8	CA	3	GALIUM TRIFLORUM	0.3	1.71	0.8	0.51	0.15	0.29	0.22
26	87	7	8	CA	3	GEUM ALEPPICUM	0.2	1.14	0.3	0.19	0.10	0.19	0.15
27	87	7	8	CA	3	GEUM MACROPHYLLUM	0.5	2.86	0.9	0.58	0.25	0.48	0.38
28	87	7	8	CA	3	GRASSES	1.0	5.71	0.0	0.00	0.50	0.97	0.75
29	87	7	8	CA	3	LATHYRUS OCHROLEUCUS	0.7	4.00	2.2	1.41	0.85	1.65	0.77
30	87	7	8	CA	3	LATHYRUS VENOSUS	0.4	2.29	0.7	0.45	0.20	0.39	0.30
31	87	7	8	CA	3	LYSIMACHIA CILIATA	0.5	2.86	1.5	0.96	0.25	0.48	0.38
32	87	7	8	CA	3	MAIANTHEMUM CANADENSE	0.7	4.00	8.1	5.20	0.35	0.68	0.52
33	87	7	8	CA	3	MERTENSIA PANICULATA	0.5	2.86	4.0	2.57	0.75	1.45	0.63
34	87	7	8	CA	3	MITELLA NUDA	0.6	3.43	7.2	4.62	0.30	0.58	0.45
35	87	7	8	CA	3	PETASITES PALMATUS	0.3	1.71	0.9	0.58	0.15	0.29	0.22
36	87	7	8	CA	3	PYROLA SPP.	0.3	1.71	0.4	0.26	0.15	0.29	0.22
37	87	7	8	CA	3	RUBUS PUBESCENS	0.4	2.29	1.4	0.90	0.20	0.39	0.30
38	87	7	8	CA	3	SMILACINA STELLATA	0.1	0.57	0.7	0.45	0.05	0.10	0.07
39	87	7	8	CA	3	SOLIDAGO SPP.	0.1	0.57	0.4	0.26	0.05	0.10	0.07
40	87	7	8	CA	3	SONCHUS SPP.	0.6	3.43	3.2	2.05	0.80	1.55	0.70
41	87	7	8	CA	3	TARAXACUM OFFICINALE	0.4	2.29	0.9	0.58	0.20	0.39	0.30
42	87	7	8	CA	3	THALICTRUM VENULOSUM	0.2	1.14	1.2	0.77	0.10	0.19	0.15
43	87	7	8	CA	3	TRIENTALIS BOREALIS	0.3	1.71	1.3	0.83	0.15	0.29	0.22
44	87	7	8	CA	3	VIOLA SPP.	0.8	4.57	5.8	3.72	0.40	0.77	0.60
45	87	7	8	CA	4	CALLIERGON RICHARDSONII	1.0	90.91	0.0	.	0.50	90.91	0.75
46	87	7	8	CA	4	PELTIGERA SPP.	0.1	9.09	0.0	.	0.05	9.09	0.07

Appendix A Cont'd

Physical characteristics of the herbaceous plants at Sandy River West, 1985 to 1987.

OBS	YR	MO	DY	SITE	STRATA	SPECIES	FREQ	RFREQ	DEN	RDEN	COV	RCOV	ASSOC
1	85	7	17	TB	1	POPULUS TREMULOIDES	0.1	100.00	0.1	100.00	0.05	100.00	0.07
2	85	7	17	TB	2	RIBES TRISTE	0.2	10.00	0.8	3.05	1.10	3.32	0.65
3	85	7	17	TB	2	ROSA ACICULARIS	0.5	25.00	0.9	3.44	5.15	15.56	2.82
4	85	7	17	TB	2	RUBUS IDAEUS	1.0	50.00	22.1	84.35	19.50	58.91	10.25
5	85	7	17	TB	2	SALIX SPP.	0.3	15.00	2.4	9.16	7.35	22.21	3.82
6	85	7	17	TB	3	ACHILLEA MILLEFOLIUM	0.6	5.00	7.1	6.30	2.50	1.79	1.55
7	85	7	17	TB	3	ANEMONE CANADENSIS	0.8	6.67	6.6	5.86	6.50	4.64	3.65
8	85	7	17	TB	3	AQUILEGIA CANADENSIS	0.4	3.33	4.0	3.55	1.70	1.21	1.05
9	85	7	17	TB	3	ASTER CILIOLATUS	0.5	4.17	7.8	6.92	9.55	6.82	5.02
10	85	7	17	TB	3	CIRSIUM ARVENSE	0.8	6.67	3.4	3.02	7.50	5.36	4.15
11	85	7	17	TB	3	CIRSIUM SPP.	0.9	7.50	4.5	3.99	7.05	5.04	3.97
12	85	7	17	TB	3	DRYOPTERIS SPINULOSA	0.2	1.67	0.4	0.35	0.60	0.43	0.40
13	85	7	17	TB	3	EPILOBIUM ANGUSTIFOLIUM	1.0	8.33	10.6	9.41	24.00	17.14	12.50
14	85	7	17	TB	3	EQUISETUM SYLVATICUM	0.4	3.33	2.8	2.48	5.30	3.79	2.85
15	85	7	17	TB	3	FRAGARIA GLAUCA	1.0	8.33	23.7	21.03	12.70	9.07	6.85
16	85	7	17	TB	3	GALIUM BOREALE	0.4	3.33	13.4	11.89	2.40	1.71	1.40
17	85	7	17	TB	3	GALIUM TRIFLORUM	0.3	2.50	0.5	0.44	0.15	0.11	0.22
18	85	7	17	TB	3	GEUM ALEPPICUM	0.4	3.33	1.6	1.42	2.90	2.07	1.65
19	85	7	17	TB	3	GEUM MACROPHYLLUM	0.2	1.67	0.3	0.27	0.10	0.07	0.15
20	85	7	17	TB	3	GRASSES	1.0	8.33	0.0	0.00	40.50	28.93	20.75
21	85	7	17	TB	3	LATHYRUS OCHROLEUCUS	0.2	1.67	0.3	0.27	1.10	0.79	0.65
22	85	7	17	TB	3	LATHYRUS VENOSUS	0.2	1.67	0.3	0.27	0.10	0.07	0.15
23	85	7	17	TB	3	MAIANTHEMUM CANADENSE	0.2	1.67	0.9	0.80	0.60	0.43	0.40
24	85	7	17	TB	3	MERTENSIA PANICULATA	0.4	3.33	3.2	2.84	5.80	4.14	3.10
25	85	7	17	TB	3	PETASITES PALMATUS	0.5	4.17	2.8	2.48	4.65	3.32	2.57
26	85	7	17	TB	3	POTENTILLA PENSYLVANICA	0.1	0.83	0.1	0.09	0.05	0.04	0.07
27	85	7	17	TB	3	RUBUS PUBESCENS	0.2	1.67	0.2	0.18	0.10	0.07	0.15
28	85	7	17	TB	3	SANICULA MARILANDICA	0.1	0.83	0.2	0.18	0.55	0.39	0.32
29	85	7	17	TB	3	TARAXACUM OFFICINALE	0.3	2.50	0.4	0.35	0.15	0.11	0.22
30	85	7	17	TB	3	VIOLA SPP.	0.9	7.50	17.6	15.62	3.45	2.46	2.17

Appendix A Cont'd

Physical characteristics of the herbaceous plants at Sandy River West, 1985 to 1987.

OBS	YR	MO	DY	SITE	STRATA	SPECIES	FREQ	RFREQ	DEN	RDEN	COV	RCOV	ASSOC
1	86	7	16	TB	1	BETULA PAPYRIFERA	0.1	50.00	0.4	80.00	0.55	91.67	0.32
2	86	7	16	TB	1	POPULUS TREMULOIDES	0.1	50.00	0.1	20.00	0.05	8.33	0.07
3	86	7	16	TB	2	DIERVILLA LONICERA	0.1	4.35	0.3	1.65	0.55	2.04	0.32
4	86	7	16	TB	2	RIBES TRISTE	0.3	13.04	0.9	4.95	1.15	4.27	0.72
5	86	7	16	TB	2	ROSA ACICULARIS	0.5	21.74	1.2	6.59	2.95	10.95	1.72
6	86	7	16	TB	2	RUBUS IDAEUS	1.0	43.48	12.9	70.88	13.40	49.72	7.20
7	86	7	16	TB	2	SALIX SPP.	0.1	4.35	2.5	13.74	8.25	30.61	4.17
8	86	7	16	TB	2	VACCINIUM ANGUSTIFOLIUM	0.2	8.70	0.2	1.10	0.10	0.37	0.15
9	86	7	16	TB	2	VIBURNUM TRILOBUM	0.1	4.35	0.2	1.10	0.55	2.04	0.32
10	86	7	16	TB	3	ACHILLEA MILLEFOLIUM	0.5	3.18	3.1	2.64	4.15	2.25	2.32
11	86	7	16	TB	3	ANEMONE CANADENSIS	1.0	6.37	6.2	5.27	8.10	4.39	4.55
12	86	7	16	TB	3	AQUILEGIA CANADENSIS	0.7	4.46	1.9	1.62	1.85	1.00	1.27
13	86	7	16	TB	3	ASTER CILIOLATUS	1.0	6.37	13.1	11.14	11.50	6.24	6.25
14	86	7	16	TB	3	ASTER PUNICEUS	0.1	0.64	1.0	0.85	0.55	0.30	0.32
15	86	7	16	TB	3	CIRSIUM ARVENSE	0.7	4.46	2.8	2.38	4.55	2.47	2.62
16	86	7	16	TB	3	CIRSIUM SPP.	0.8	5.10	4.2	3.57	4.60	2.50	2.70
17	86	7	16	TB	3	DRYOPTERIS SPINULOSA	0.1	0.64	0.4	0.34	0.55	0.30	0.32
18	86	7	16	TB	3	EPILOBIUM ANGUSTIFOLIUM	1.0	6.37	13.3	11.31	11.50	6.24	6.25
19	86	7	16	TB	3	EQUISETUM SYLVATICUM	0.6	3.82	7.0	5.95	6.40	3.47	3.50
20	86	7	16	TB	3	FRAGARIA GLAUCA	1.0	6.37	20.5	17.43	13.90	7.54	7.45
21	86	7	16	TB	3	GALIUM BOREALE	0.5	3.18	6.3	5.36	3.45	1.87	1.97
22	86	7	16	TB	3	GALIUM TRIFLORUM	0.4	2.55	0.7	0.60	1.20	0.65	0.80
23	86	7	16	TB	3	GEOCAULON LIVIDUM	0.1	0.64	0.4	0.34	0.05	0.03	0.07
24	86	7	16	TB	3	GEUM ALEPPICUM	0.6	3.82	4.2	3.57	4.00	2.17	2.30
25	86	7	16	TB	3	GEUM MACROPHYLLUM	0.7	4.46	3.2	2.72	4.05	2.20	2.37
26	86	7	16	TB	3	GRASSES	1.0	6.37	0.0	0.00	75.70	41.06	38.35
27	86	7	16	TB	3	LATHYRUS OCHROLEUCUS	0.1	0.64	0.1	0.09	0.05	0.03	0.07
28	86	7	16	TB	3	LATHYRUS VENOSUS	0.6	3.82	1.4	1.19	1.80	0.98	1.20
29	86	7	16	TB	3	LINNAEA BOREALIS	0.1	0.64	0.3	0.26	0.55	0.30	0.32
30	86	7	16	TB	3	MAIANTHEMUM CANADENSE	0.5	3.18	1.6	1.36	1.75	0.95	1.13
31	86	7	16	TB	3	MENTHA ARVENSIS	0.1	0.64	0.5	0.43	0.55	0.30	0.32
32	86	7	16	TB	3	MERTENSIA PANICULATA	0.4	2.55	2.8	2.38	3.40	1.84	1.90
33	86	7	16	TB	3	MITELLA NUDA	0.2	1.27	0.6	0.51	0.60	0.33	0.40
34	86	7	16	TB	3	PETASITES PALMATUS	0.5	3.18	0.6	0.51	0.25	0.14	0.38
35	86	7	16	TB	3	PETASITES VITIFOLIUS	0.1	0.64	1.0	0.85	1.75	0.95	0.92
36	86	7	16	TB	3	RUBUS PUBESCENS	0.3	1.91	1.5	1.28	1.65	0.90	0.97
37	86	7	16	TB	3	SMILACINA STELLATA	0.2	1.27	0.7	0.60	0.60	0.33	0.40
38	86	7	16	TB	3	SONCHUS SPP.	0.3	1.91	2.6	2.21	2.35	1.27	1.32
39	86	7	16	TB	3	TARAXACUM OFFICIONALIS	0.4	2.55	0.4	0.34	0.20	0.11	0.30
40	86	7	16	TB	3	TRIENTALIS BOREALIS	0.1	0.64	1.1	0.94	1.75	0.95	0.92
41	86	7	16	TB	3	VIOLA SPP.	1.0	6.37	14.1	11.99	11.00	5.97	6.00

Physical characteristics of the herbaceous plants at Sandy River West, 1985 to 1987.

OBS	YR	MO	DY	SITE	STRATA	SPECIES	FREQ	RFREQ	DEN	RDEN	COV	RCOV	ASSOC
1	87	7	9	TB	2	ROSA ACICULARIS	0.5	27.78	1.0	9.35	0.25	10.42	0.38
2	87	7	9	TB	2	RUBUS IDAEUS	1.0	55.56	6.8	63.55	1.50	62.50	1.25
3	87	7	9	TB	2	SALIX SPP.	0.1	5.56	2.0	18.69	0.55	22.92	0.32
4	87	7	9	TB	2	VACCINIUM ANGUSTIFOLIUM	0.2	11.11	0.9	8.41	0.10	4.17	0.15
5	87	7	9	TB	3	ACHILLEA MILLEFOLIUM	0.6	3.82	6.2	3.64	0.80	1.94	0.70
6	87	7	9	TB	3	ANEMONE CANADENSIS	0.9	5.73	21.6	12.67	4.15	10.09	2.52
7	87	7	9	TB	3	AQUILEGIA CANADENSIS	0.5	3.18	2.1	1.23	0.25	0.61	0.38
8	87	7	9	TB	3	ARALIA NUDICAULIS	0.1	0.64	0.1	0.06	0.05	0.12	0.07
9	87	7	9	TB	3	ASTER CILIOLATUS	1.0	6.37	28.4	16.66	5.70	13.85	3.35
10	87	7	9	TB	3	CIRSIUM ARVENSE	0.7	4.46	1.7	1.00	0.35	0.85	0.52
11	87	7	9	TB	3	CIRSIUM SPP.	0.5	3.18	1.0	0.59	0.25	0.61	0.38
12	87	7	9	TB	3	CORNUS CANADENSIS	0.1	0.64	0.4	0.23	0.05	0.12	0.07
13	87	7	9	TB	3	DRYOPTERIS SPINULOSA	0.1	0.64	0.1	0.06	0.05	0.12	0.07
14	87	7	9	TB	3	EPILOBIUM ANGUSTIFOLIUM	1.0	6.37	12.4	7.27	1.50	3.65	1.25
15	87	7	9	TB	3	EQUISETUM SYLVATICUM	0.5	3.18	5.0	2.93	0.75	1.82	0.63
16	87	7	9	TB	3	FRAGARIA GLAUCA	1.0	6.37	20.8	12.20	3.20	7.78	2.10
17	87	7	9	TB	3	GALIUM BOREALE	0.3	1.91	6.2	3.64	0.65	1.58	0.47
18	87	7	9	TB	3	GALIUM TRIFLORUM	0.3	1.91	0.3	0.18	0.15	0.36	0.22
19	87	7	9	TB	3	GEOCAULON LIVIDUM	0.1	0.64	0.2	0.12	0.05	0.12	0.07
20	87	7	9	TB	3	GEUM MACROPHYLLUM	0.9	5.73	5.9	3.46	0.95	2.31	0.92
21	87	7	9	TB	3	GRASSES	1.0	6.37	0.0	0.00	8.90	21.63	4.95
22	87	7	9	TB	3	LATHYRUS OCHROLEUCUS	0.5	3.18	1.1	0.65	0.25	0.61	0.38
23	87	7	9	TB	3	LATHYRUS VENOSUS	0.5	3.18	2.3	1.35	0.25	0.61	0.38
24	87	7	9	TB	3	LYSIMACHIA CILIATA	0.7	4.46	5.7	3.34	0.85	2.07	0.77
25	87	7	9	TB	3	MAIANTHEMUM CANADENSE	0.4	2.55	1.0	0.59	0.20	0.49	0.30
26	87	7	9	TB	3	MENTHA ARVENSIS	0.1	0.64	0.1	0.06	0.05	0.12	0.07
27	87	7	9	TB	3	MERTENSIA PANICULATA	0.5	3.18	1.2	0.70	0.25	0.61	0.38
28	87	7	9	TB	3	MITELLA NUDA	0.1	0.64	0.3	0.18	0.05	0.12	0.07
29	87	7	9	TB	3	PETASITES PALMATUS	0.3	1.91	1.0	0.59	0.15	0.36	0.22
30	87	7	9	TB	3	RUBUS PUBESCENS	0.4	2.55	3.2	1.88	0.20	0.49	0.30
31	87	7	9	TB	3	SANICULA MARILANDICA	0.1	0.64	0.3	0.18	0.05	0.12	0.07
32	87	7	9	TB	3	SOLIDAGO SPP.	0.2	1.27	0.2	0.12	0.10	0.24	0.15
33	87	7	9	TB	3	SONCHUS ARVENSIS	0.1	0.64	0.4	0.23	0.05	0.12	0.07
34	87	7	9	TB	3	SONCHUS SPP.	0.7	4.46	6.5	3.81	2.55	6.20	1.62
35	87	7	9	TB	3	TARAXACUM OFFICINALE	0.4	2.55	0.9	0.53	0.20	0.49	0.30
36	87	7	9	TB	3	TRIENTALIS BOREALIS	0.1	0.64	0.2	0.12	0.05	0.12	0.07
37	87	7	9	TB	3	VIOLA SPP.	1.0	6.37	33.7	19.77	8.10	19.68	4.55

Appendix A Cont'd

Physical characteristics of the herbaceous plants at Sandy River West, 1985 to 1987.

OBS	YR	MO	DY	SITE	STRATA	SPECIES	FREQ	RFREQ	DEN	RDEN	COV	RCOV	ASSOC
1	85	7	16	CB	1	POPULUS TREMULOIDES	0.5	100.00	1.4	100.00	4.15	100.00	2.32
2	85	7	16	CB	2	ROSA ACICULARIS	0.4	22.22	2.0	6.60	4.10	12.42	2.25
3	85	7	16	CB	2	RUBUS IDAEUS	1.0	55.56	25.6	84.49	21.10	63.94	11.05
4	85	7	16	CB	2	SALIX SPP.	0.4	22.22	2.7	8.91	7.80	23.64	4.10
5	85	7	16	CB	3	AQUILEGIA CANADENSIS	0.2	2.22	0.8	0.75	8.80	6.39	4.50
6	85	7	16	CB	3	ASTER CILIOLATUS	0.2	2.22	6.2	5.78	2.30	1.67	1.25
7	85	7	16	CB	3	ASTER PUNICEUS	0.1	1.11	0.1	0.09	0.05	0.04	0.07
8	85	7	16	CB	3	CHENOPODIUM ALBUM	0.1	1.11	0.5	0.47	0.55	0.40	0.32
9	85	7	16	CB	3	CIRSIUM ARVENSE	0.9	10.00	4.7	4.38	6.85	4.97	3.87
10	85	7	16	CB	3	CIRSIUM SPP.	0.2	2.22	0.4	0.37	0.60	0.44	0.40
11	85	7	16	CB	3	EPILOBIUM ANGUSTIFOLIUM	0.6	6.67	1.2	1.12	0.80	0.58	0.70
12	85	7	16	CB	3	EQUISETUM SYLVATICUM	0.8	8.89	3.0	2.80	2.40	1.74	1.60
13	85	7	16	CB	3	FRAGARIA GLAUCA	0.5	5.56	5.8	5.41	4.15	3.01	2.32
14	85	7	16	CB	3	GALIUM BOREALE	0.7	7.78	63.8	59.46	31.15	22.61	15.92
15	85	7	16	CB	3	GRASSES	1.0	11.11	0.0	0.00	54.30	39.40	27.65
16	85	7	16	CB	3	LATHYRUS OCHROLEUCUS	0.3	3.33	1.1	1.03	2.35	1.71	1.32
17	85	7	16	CB	3	LATHYRUS VENOSUS	1.0	11.11	5.1	4.75	11.70	8.49	6.35
18	85	7	16	CB	3	MAIANTHEMUM CANADENSE	0.1	1.11	1.1	1.03	0.55	0.40	0.32
19	85	7	16	CB	3	MENTHA ARVENSIS	0.4	4.44	2.0	1.86	2.90	2.10	1.65
20	85	7	16	CB	3	MERTENSIA PANICULATA	0.2	2.22	2.0	1.86	1.10	0.80	0.65
21	85	7	16	CB	3	PETASITES PALMATUS	0.1	1.11	0.2	0.19	0.05	0.04	0.07
22	85	7	16	CB	3	POLYGONUM CONVOLVULUS	0.3	3.33	0.4	0.37	0.65	0.47	0.47
23	85	7	16	CB	3	RANUNCULUS SPP.	0.1	1.11	0.2	0.19	0.05	0.04	0.07
24	85	7	16	CB	3	SONCHUS ARVENSIS	0.4	4.44	1.3	1.21	2.90	2.10	1.65
25	85	7	16	CB	3	TARAXACUM OFFICINALE	0.3	3.33	0.6	0.56	1.85	1.34	1.07
26	85	7	16	CB	3	VIOLA SPP.	0.5	5.56	6.8	6.34	1.75	1.27	1.13

Physical characteristics of the herbaceous plants at Sandy River West, 1985 to 1987.

OBS	YR	MO	DY	SITE	STRATA	SPECIES	FREQ	RFREQ	DEN	RDEN	COV	RCOV	ASSOC
1	86	7	15	CB	1	POPULUS TREMULOIDES	0.3	100.00	0.9	100.00	5.55	100.00	2.92
2	86	7	15	CB	2	ROSA ACICULARIS	0.4	22.22	2.2	12.43	3.40	19.10	1.90
3	86	7	15	CB	2	RUBUS IDAEUS	0.9	50.00	12.6	71.19	9.25	51.97	5.07
4	86	7	15	CB	2	SALIX SPP.	0.5	27.78	2.9	16.38	5.15	28.93	2.82
5	86	7	15	CB	3	AQUILEGIA CANADENSIS	0.2	1.68	3.3	2.29	0.60	0.38	0.40
6	86	7	15	CB	3	ASTER CILIOLATUS	0.8	6.72	7.0	4.85	3.60	2.30	2.20
7	86	7	15	CB	3	ASTER PUNICEUS	0.1	0.84	1.3	0.90	0.55	0.35	0.32
8	86	7	15	CB	3	CAREX SPP.	0.2	1.68	2.6	1.80	0.60	0.38	0.40
9	86	7	15	CB	3	CHENOPODIUM SPP.	0.1	0.84	0.1	0.07	0.05	0.03	0.07
10	86	7	15	CB	3	CIRSIUM ARVENSE	0.8	6.72	9.8	6.79	11.00	7.02	5.90
11	86	7	15	CB	3	CIRSIUM SPP.	0.3	2.52	0.3	0.21	0.65	0.41	0.47
12	86	7	15	CB	3	EPILOBIUM ANGUSTIFOLIUM	0.5	4.20	1.0	0.69	0.75	0.48	0.63
13	86	7	15	CB	3	EQUISETUM SYLVATICUM	0.8	6.72	5.4	3.74	2.40	1.53	1.60
14	86	7	15	CB	3	FRAGARIA GLAUCA	0.8	6.72	11.3	7.83	3.90	2.49	2.35
15	86	7	15	CB	3	GALIUM BOREALE	0.8	6.72	76.0	52.63	35.20	22.46	18.00
16	86	7	15	CB	3	GEUM MACROPHYLLUM	0.3	2.52	0.5	0.35	0.15	0.10	0.22
17	86	7	15	CB	3	GRASSES	1.0	8.40	0.0	0.00	75.90	48.42	38.45
18	86	7	15	CB	3	LATHYRUS OCHROLEUCUS	0.4	3.36	0.9	0.62	1.20	0.77	0.80
19	86	7	15	CB	3	LATHYRUS VENOSUS	0.8	6.72	10.4	7.20	10.00	6.38	5.40
20	86	7	15	CB	3	MAIANTHEMUM CANADENSE	0.4	3.36	3.1	2.15	1.20	0.77	0.80
21	86	7	15	CB	3	MENTHA ARVENSIS	0.8	6.72	4.3	2.98	2.40	1.53	1.60
22	86	7	15	CB	3	MERTENSIA PANICULATA	0.2	1.68	0.4	0.28	0.60	0.38	0.40
23	86	7	15	CB	3	PETASITES PALMATUS	0.1	0.84	0.1	0.07	0.05	0.03	0.07
24	86	7	15	CB	3	POLYGONUM CONVOLVULUS	0.1	0.84	0.1	0.07	0.05	0.03	0.07
25	86	7	15	CB	3	PYROLA ELLIPTICA	0.1	0.84	0.1	0.07	0.05	0.03	0.07
26	86	7	15	CB	3	RANUNCULUS SPP.	0.3	2.52	0.3	0.21	0.15	0.10	0.22
27	86	7	15	CB	3	RUBUS PUBESCENS	0.4	3.36	1.4	0.97	1.20	0.77	0.80
28	86	7	15	CB	3	SOLIDAGO SPP.	0.5	4.20	1.0	0.69	0.25	0.16	0.38
29	86	7	15	CB	3	SONCHUS ARVENSIS	0.7	5.88	2.0	1.39	3.55	2.26	2.12
30	86	7	15	CB	3	TARAXACUM OFFICINALE	0.3	2.52	1.6	1.11	0.65	0.41	0.47
31	86	7	15	CB	3	TRIENTALIS BOREALIS	0.1	0.84	0.1	0.07	0.05	0.03	0.07

Physical characteristics of the herbaceous plants at Sandy River West, 1985 to 1987.

OBS	YR	MO	DY	SITE	STRATA	SPECIES	FREQ	RFREQ	DEN	RDEN	COV	RCOV	ASSOC
1	87	7	8	CB	1	POPULUS TREMULOIDES	0.4	100.00	1.0	100.00	4.10	100.00	2.25
2	87	7	8	CB	2	RIBES SPP.	0.1	5.56	0.1	0.57	0.05	0.50	0.07
3	87	7	8	CB	2	ROSA ACICULARIS	0.5	27.78	3.3	18.86	1.25	12.50	0.88
4	87	7	8	CB	2	RUBUS IDAEUS	0.8	44.44	12.5	71.43	4.10	41.00	2.45
5	87	7	8	CB	2	SALIX SPP.	0.4	22.22	1.6	9.14	4.60	46.00	2.50
6	87	7	8	CB	3	AQUILEGIA CANADENSIS	0.1	1.06	0.1	0.09	0.55	1.07	0.32
7	87	7	8	CB	3	ASTER CILIOLATUS	0.8	8.51	15.0	13.85	2.40	4.65	1.60
8	87	7	8	CB	3	CAREX SPP.	0.2	2.13	2.1	1.94	0.10	0.19	0.15
9	87	7	8	CB	3	CIRSIUM ARVENSE	1.0	10.64	7.9	7.29	1.50	2.91	1.25
10	87	7	8	CB	3	CIRSIUM SPP.	0.2	2.13	0.6	0.55	0.10	0.19	0.15
11	87	7	8	CB	3	CORNUS CANADENSIS	0.1	1.06	0.1	0.09	0.05	0.10	0.07
12	87	7	8	CB	3	EPILOBIUM ANGUSTIFOLIUM	0.4	4.26	2.5	2.31	0.20	0.39	0.30
13	87	7	8	CB	3	EQUISETUM SYLVATICUM	0.1	1.06	0.1	0.09	0.05	0.10	0.07
14	87	7	8	CB	3	FRAGARIA GLAUCA	0.6	6.38	8.6	7.94	2.30	4.46	1.45
15	87	7	8	CB	3	GALIUM BOREALE	0.6	6.38	45.0	41.55	17.10	33.14	8.85
16	87	7	8	CB	3	GEUM MACROPHYLLUM	0.3	3.19	0.5	0.46	0.15	0.29	0.22
17	87	7	8	CB	3	GRASSES	1.0	10.64	0.0	0.00	22.10	42.83	11.55
18	87	7	8	CB	3	LATHYRUS OCHROLEUCUS	0.6	6.38	2.9	2.68	0.30	0.58	0.45
19	87	7	8	CB	3	LATHYRUS VENOSUS	0.6	6.38	3.7	3.42	0.80	1.55	0.70
20	87	7	8	CB	3	MAIANTHEMUM CANADENSE	0.2	2.13	3.0	2.77	0.60	1.16	0.40
21	87	7	8	CB	3	MENTHA ARVENSIS	0.6	6.38	4.6	4.25	0.80	1.55	0.70
22	87	7	8	CB	3	MERTENSIA PANICULATA	0.2	2.13	1.6	1.48	0.60	1.16	0.40
23	87	7	8	CB	3	PETASITES PALMATUS	0.1	1.06	0.1	0.09	0.05	0.10	0.07
24	87	7	8	CB	3	RUBUS PUBESCENS	0.6	6.38	2.4	2.22	0.30	0.58	0.45
25	87	7	8	CB	3	SOLIDAGO SPP.	0.1	1.06	0.2	0.18	0.05	0.10	0.07
26	87	7	8	CB	3	SONCHUS ARVENSIS	0.5	5.32	5.7	5.26	1.25	2.42	0.88
27	87	7	8	CB	3	TARAXACUM OFFICINALE	0.4	4.26	1.5	1.39	0.20	0.39	0.30
28	87	7	8	CB	3	TRIENTALIS BOREALIS	0.1	1.06	0.1	0.09	0.05	0.10	0.07

Appendix A Cont'd

Physical characteristics of the herbaceous plants at Sandy River West, 1985 to 1987.

OBS	YR	MO	DY	SITE	STRATA	SPECIES	FREQ	RFREQ	DEN	RDEN	COV	RCOV	ASSOC
1	87	7	14	NT	1	POPULUS TREMULOIDES	0.1	100.00	0.1	100.00	0.05	100.00	0.07
2	87	7	14	NT	2	LONICERA CANADENSIS	0.1	3.33	0.9	5.70	0.05	0.81	0.07
3	87	7	14	NT	2	ROSA ACICULARIS	0.9	30.00	4.6	29.11	1.45	23.39	1.17
4	87	7	14	NT	2	RUBUS IDAEUS	0.9	30.00	6.3	39.87	4.15	66.94	2.52
5	87	7	14	NT	2	SYMPHORICARPOS OCCIDENTALIS	0.8	26.67	3.6	22.78	0.40	6.45	0.60
6	87	7	14	NT	2	VACCINIUM ANGUSTIFOLIUM	0.2	6.67	0.2	1.27	0.10	1.61	0.15
7	87	7	14	NT	2	VIBURNUM EDULE	0.1	3.33	0.2	1.27	0.05	0.81	0.07
8	87	7	14	NT	3	ACHILLEA MILLEFOLIUM	0.3	1.91	0.7	0.64	0.15	0.25	0.22
9	87	7	14	NT	3	ANEMONE CANADENSIS	1.0	6.37	17.1	15.55	5.90	9.68	3.45
10	87	7	14	NT	3	AQUILEGIA CANADENSIS	0.9	5.73	5.5	5.00	1.45	2.38	1.17
11	87	7	14	NT	3	ARALIA NUDICAULIS	0.7	4.46	4.1	3.73	0.85	1.39	0.77
12	87	7	14	NT	3	ASTER CILIOLATUS	1.0	6.37	9.7	8.82	3.20	5.25	2.10
13	87	7	14	NT	3	CIRSIUM ARVENSE	0.1	0.64	0.1	0.09	0.05	0.08	0.07
14	87	7	14	NT	3	CIRSIUM SPP.	0.2	1.27	0.3	0.27	0.10	0.16	0.15
15	87	7	14	NT	3	EPILOBIUM ANGUSTIFOLIUM	0.2	1.27	1.0	0.91	0.10	0.16	0.15
16	87	7	14	NT	3	EQUISETUM SYLVATICUM	0.1	0.64	0.1	0.09	0.05	0.08	0.07
17	87	7	14	NT	3	FRAGARIA GLAUCA	0.9	5.73	14.7	13.36	7.55	12.39	4.22
18	87	7	14	NT	3	GALIUM BOREALE	1.0	6.37	11.6	10.55	0.50	0.82	0.75
19	87	7	14	NT	3	GEUM MACROPHYLLUM	0.1	0.64	0.1	0.09	0.05	0.08	0.07
20	87	7	14	NT	3	GRASSES	1.0	6.37	0.0	0.00	3.00	4.92	2.00
21	87	7	14	NT	3	LACTUCA HIRSUTA	0.2	1.27	1.3	1.18	3.50	5.74	1.85
22	87	7	14	NT	3	LATHYRUS OCHROLEUCUS	1.0	6.37	18.4	16.73	24.30	39.87	12.65
23	87	7	14	NT	3	LATHYRUS VENOSUS	0.8	5.10	1.5	1.36	0.40	0.66	0.60
24	87	7	14	NT	3	LYSIMACHIA CILIATA	0.3	1.91	1.1	1.00	0.15	0.25	0.22
25	87	7	14	NT	3	MAIANTHEMUM CANADENSE	0.7	4.46	1.4	1.27	0.35	0.57	0.52
26	87	7	14	NT	3	MERTENSIA PANICULATA	0.3	1.91	0.6	0.55	0.15	0.25	0.22
27	87	7	14	NT	3	PETASITES PALMATUS	0.1	0.64	0.4	0.36	0.05	0.08	0.07
28	87	7	14	NT	3	PYROLA SPP.	0.2	1.27	0.5	0.45	0.10	0.16	0.15
29	87	7	14	NT	3	RUBUS PUBESCENS	1.0	6.37	3.1	2.82	1.00	1.64	1.00
30	87	7	14	NT	3	SANICULA MARILANDICA	0.7	4.46	1.9	1.73	1.35	2.21	1.02
31	87	7	14	NT	3	SMILACINA STELLATA	0.8	5.10	2.8	2.55	0.90	1.48	0.85
32	87	7	14	NT	3	SOLIDAGO SPP.	0.4	2.55	3.1	2.82	2.40	3.94	1.40
33	87	7	14	NT	3	TARAXACUM OFFICINALE	0.7	4.46	1.6	1.45	1.35	2.21	1.02
34	87	7	14	NT	3	VIOLA SPP.	1.0	6.37	7.3	6.64	2.00	3.28	1.50
35	87	7	14	NT	4	LICHEN	0.3	27.27	0.0	.	0.15	27.27	0.22
36	87	7	14	NT	4	MOSS	0.8	72.73	0.0	.	0.40	72.73	0.60

Appendix A Cont'd

VEGETATION PARAMETERS FOR INDICATOR SPECIES
AT ASPEN SITES, SANDY RIVER WEST, 1985-1987

SITE=TREATED ASPEN

YEAR	STRATA	SPECIES	FREQUENCY	COVER	ASSOCIATION VALUE
85	SHRUB	ROSA ACICULARIS	0.9	15.35	8.12
85	SHRUB	RUBUS IDAEUS	1.0	13.90	7.45
85	SHRUB	SYMPHORICARPOS OCCIDENTALIS	0.7	5.25	2.97
85	HERB	AQUILEGIA CANADENSIS	0.1	0.55	0.32
85	HERB	ASTER CILIOLATUS	0.7	5.95	3.32
85	HERB	CIRSIUM SPP.	0.4	2.40	1.40
85	HERB	EPILOBIUM ANGUSTIFOLIUM	0.6	2.80	1.70
85	HERB	EQUISETUM SYLVATICUM	0.3	0.65	0.47
85	HERB	GALIUM BOREALE	0.9	9.75	5.32
85	HERB	GRASSES	1.0	47.60	24.30
85	HERB	MAIANTHEMUM CANADENSE	0.9	4.15	2.52
85	HERB	MERTENSIA PANICULATA	0.5	3.95	2.22
85	HERB	PETASITES PALMATUS	0.7	4.05	2.37
85	HERB	RUBUS PUBESCENS	0.6	5.70	3.15
85	HERB	SMILACINA STELLATA	0.4	2.90	1.65
85	HERB	VIOLA SPP.	0.3	0.65	0.47
85	MOSS & LICHEN	CALLIERGON RICHARDSONII	0.8	3.10	1.95
85	MOSS & LICHEN	CLADONIA SPP.	0.2	1.80	1.00
86	SHRUB	ROSA ACICULARIS	0.9	16.85	8.87
86	SHRUB	RUBUS IDAEUS	1.0	8.80	4.90
86	SHRUB	SYMPHORICARPOS OCCIDENTALIS	0.7	5.05	2.87
86	HERB	AQUILEGIA CANADENSIS	0.5	1.75	1.13
86	HERB	ASTER CILIOLATUS	0.8	7.80	4.30
86	HERB	CIRSIUM SPP.	0.6	2.30	1.45
86	HERB	EPILOBIUM ANGUSTIFOLIUM	0.5	1.75	1.13
86	HERB	EQUISETUM SYLVATICUM	0.7	1.35	1.02
86	HERB	GALIUM BOREALE	1.0	9.10	5.05
86	HERB	GRASSES	1.0	39.00	20.00
86	HERB	MAIANTHEMUM CANADENSE	0.8	4.40	2.60
86	HERB	MERTENSIA PANICULATA	0.5	5.45	2.97
86	HERB	PETASITES PALMATUS	0.6	4.00	2.30
86	HERB	RUBUS PUBESCENS	0.7	6.25	3.47
86	HERB	SMILACINA STELLATA	0.6	2.50	1.55
86	HERB	VIOLA SPP.	0.6	1.30	0.95
86	MOSS & LICHEN	CALLIERGON RICHARDSONII	1.0	7.10	4.05
86	MOSS & LICHEN	CLADONIA SPP.	0.5	4.15	2.32
87	SHRUB	ROSA ACICULARIS	1.0	9.60	5.30
87	SHRUB	RUBUS IDAEUS	1.0	2.00	1.50
87	SHRUB	SYMPHORICARPOS OCCIDENTALIS	0.7	0.85	0.77
87	HERB	AQUILEGIA CANADENSIS	0.2	0.10	0.15
87	HERB	ASTER CILIOLATUS	0.8	2.40	1.60
87	HERB	CIRSIUM SPP.	0.4	0.20	0.30
87	HERB	EPILOBIUM ANGUSTIFOLIUM	0.5	1.25	0.88
87	HERB	EQUISETUM SYLVATICUM	0.5	0.25	0.38
87	HERB	GALIUM BOREALE	1.0	1.50	1.25
87	HERB	GRASSES	1.0	4.20	2.60
87	HERB	MAIANTHEMUM CANADENSE	0.9	0.45	0.67
87	HERB	MERTENSIA PANICULATA	0.3	0.15	0.22
87	HERB	PETASITES PALMATUS	0.7	0.85	0.77
87	HERB	RUBUS PUBESCENS	0.8	1.40	1.10
87	HERB	SMILACINA STELLATA	0.4	0.20	0.30
87	HERB	VIOLA SPP.	0.7	0.85	0.77
87	MOSS & LICHEN	CALLIERGON RICHARDSONII	1.0	1.50	1.25
87	MOSS & LICHEN	CLADONIA SPP.	0.3	0.65	0.47

VEGETATION PARAMETERS FOR INDICATOR SPECIES
AT ASPEN SITES, SANDY RIVER WEST, 1985-1987

SITE=CONTROL ASPEN

YEAR	STRATA	SPECIES	FREQUENCY	COVER	ASSOCIATION VALUE
85	SHRUB	ROSA ACICULARIS	0.9	20.05	10.47
85	SHRUB	RUBUS IDAEUS	0.9	7.05	3.97
85	SHRUB	SYMPHORICARPOS OCCIDENTALIS	0.1	1.75	0.92
85	HERB	AQUILEGIA CANADENSIS	0.5	1.25	0.88
85	HERB	ASTER CILIOLATUS	0.8	11.90	6.35
85	HERB	CIRSIUM SPP.	0.8	6.30	3.55
85	HERB	EPILOBIUM ANGUSTIFOLIUM	0.9	10.45	5.67
85	HERB	EQUISETUM SYLVATICUM	1.0	6.90	3.95
85	HERB	GALIUM BOREALE	0.9	10.45	5.67
85	HERB	GRASSES	1.0	23.60	12.30
85	HERB	MAIANTHEMUM CANADENSE	0.7	7.45	4.07
85	HERB	MERTENSIA PANICULATA	0.6	3.30	1.95
85	HERB	PETASITES PALMATUS	0.6	2.00	1.30
85	HERB	RUBUS PUBESCENS	0.3	1.65	0.97
85	HERB	SMILACINA STELLATA	0.3	2.35	1.32
85	HERB	VIOLA SPP.	0.7	1.85	1.27
85	MOSS & LICHEN	CALLIERGON RICHARDSONII	0.7	3.05	1.87
86	SHRUB	ROSA ACICULARIS	0.9	31.05	15.97
86	SHRUB	RUBUS IDAEUS	0.8	4.60	2.70
86	SHRUB	SYMPHORICARPOS OCCIDENTALIS	0.1	1.75	0.92
86	HERB	AQUILEGIA CANADENSIS	0.6	3.00	1.80
86	HERB	ASTER CILIOLATUS	1.0	26.10	13.55
86	HERB	CIRSIUM SPP.	1.0	2.50	1.75
86	HERB	EPILOBIUM ANGUSTIFOLIUM	0.9	7.05	3.97
86	HERB	EQUISETUM SYLVATICUM	1.0	6.90	3.95
86	HERB	GALIUM BOREALE	1.0	9.60	5.30
86	HERB	GRASSES	1.0	33.60	17.30
86	HERB	MAIANTHEMUM CANADENSE	0.7	2.35	1.52
86	HERB	MERTENSIA PANICULATA	0.6	6.00	3.30
86	HERB	PETASITES PALMATUS	0.4	1.20	0.80
86	HERB	RUBUS PUBESCENS	0.4	1.20	0.80
86	HERB	SMILACINA STELLATA	0.1	0.55	0.32
86	HERB	VIOLA SPP.	0.9	0.95	0.92
86	MOSS & LICHEN	CALLIERGON RICHARDSONII	1.0	4.20	2.60
87	SHRUB	ROSA ACICULARIS	0.9	23.35	12.12
87	SHRUB	RUBUS IDAEUS	0.8	0.90	0.85
87	SHRUB	SYMPHORICARPOS OCCIDENTALIS	0.2	0.60	0.40
87	HERB	AQUILEGIA CANADENSIS	0.5	0.75	0.63
87	HERB	ASTER CILIOLATUS	1.0	20.00	10.50
87	HERB	CIRSIUM SPP.	0.8	0.40	0.60
87	HERB	EPILOBIUM ANGUSTIFOLIUM	0.9	1.95	1.42
87	HERB	EQUISETUM SYLVATICUM	1.0	1.00	1.00
87	HERB	GALIUM BOREALE	1.0	1.00	1.00
87	HERB	GRASSES	1.0	0.50	0.75
87	HERB	MAIANTHEMUM CANADENSE	0.7	0.35	0.52
87	HERB	MERTENSIA PANICULATA	0.5	0.75	0.63
87	HERB	PETASITES PALMATUS	0.3	0.15	0.22
87	HERB	RUBUS PUBESCENS	0.4	0.20	0.30
87	HERB	SMILACINA STELLATA	0.1	0.05	0.07
87	HERB	VIOLA SPP.	0.8	0.40	0.60
87	MOSS & LICHEN	CALLIERGON RICHARDSONII	1.0	0.50	0.75

VEGETATION PARAMETERS FOR INDICATOR SPECIES
AT BURN SITES, SANDY RIVER WEST, 1985-1987

SITE=TREATED BURN

YEAR	STRATA	SPECIES	FREQUENCY	COVER	ASSOCIATION VALUE
85	SHRUB	ROSA ACICULARIS	0.5	5.15	2.82
85	SHRUB	RUBUS IDAEUS	1.0	19.50	10.25
85	HERB	ACHILLEA MILLEFOLIUM	0.6	2.50	1.55
85	HERB	ANEMONE CANADENSIS	0.8	6.50	3.65
85	HERB	AQUILEGIA CANADENSIS	0.4	1.70	1.05
85	HERB	ASTER CILIOLATUS	0.5	9.55	5.02
85	HERB	CIRSIUM ARVENSE	0.8	7.50	4.15
85	HERB	CIRSIUM SPP.	0.9	7.05	3.97
85	HERB	EPILOBIUM ANGUSTIFOLIUM	1.0	24.00	12.50
85	HERB	EQUISETUM SYLVATICUM	0.4	5.30	2.85
85	HERB	FRAGARIA GLAUCA	1.0	12.70	6.85
85	HERB	GALIUM BOREALE	0.4	2.40	1.40
85	HERB	GEUM ALEPPICUM	0.4	2.90	1.65
85	HERB	GEUM MACROPHYLLUM	0.2	0.10	0.15
85	HERB	GRASSES	1.0	40.50	20.75
85	HERB	LATHYRUS VENOSUS	0.2	0.10	0.15
85	HERB	MAIANTHEMUM CANADENSE	0.2	0.60	0.40
85	HERB	PETASITES PALMATUS	0.5	4.65	2.57
85	HERB	VIOLA SPP.	0.9	3.45	2.17
86	SHRUB	ROSA ACICULARIS	0.5	2.95	1.72
86	SHRUB	RUBUS IDAEUS	1.0	13.40	7.20
86	HERB	ACHILLEA MILLEFOLIUM	0.5	4.15	2.32
86	HERB	ANEMONE CANADENSIS	1.0	8.10	4.55
86	HERB	AQUILEGIA CANADENSIS	0.7	1.85	1.27
86	HERB	ASTER CILIOLATUS	1.0	11.50	6.25
86	HERB	CIRSIUM ARVENSE	0.7	4.55	2.62
86	HERB	CIRSIUM SPP.	0.8	4.60	2.70
86	HERB	EPILOBIUM ANGUSTIFOLIUM	1.0	11.50	6.25
86	HERB	EQUISETUM SYLVATICUM	0.6	6.40	3.50
86	HERB	FRAGARIA GLAUCA	1.0	13.90	7.45
86	HERB	GALIUM BOREALE	0.5	3.45	1.97
86	HERB	GEUM ALEPPICUM	0.6	4.00	2.30
86	HERB	GEUM MACROPHYLLUM	0.7	4.05	2.37
86	HERB	GRASSES	1.0	75.70	38.35
86	HERB	LATHYRUS VENOSUS	0.6	1.80	1.20
86	HERB	MAIANTHEMUM CANADENSE	0.5	1.75	1.13
86	HERB	PETASITES PALMATUS	0.5	0.25	0.38
86	HERB	VIOLA SPP.	1.0	11.00	6.00
87	SHRUB	ROSA ACICULARIS	0.5	0.25	0.38
87	SHRUB	RUBUS IDAEUS	1.0	1.50	1.25
87	HERB	ACHILLEA MILLEFOLIUM	0.6	0.80	0.70
87	HERB	ANEMONE CANADENSIS	0.9	4.15	2.52
87	HERB	AQUILEGIA CANADENSIS	0.5	0.25	0.38
87	HERB	ASTER CILIOLATUS	1.0	5.70	3.35
87	HERB	CIRSIUM ARVENSE	0.7	0.35	0.52
87	HERB	CIRSIUM SPP.	0.5	0.25	0.38
87	HERB	EPILOBIUM ANGUSTIFOLIUM	1.0	1.50	1.25
87	HERB	EQUISETUM SYLVATICUM	0.5	0.75	0.63
87	HERB	FRAGARIA GLAUCA	1.0	3.20	2.10
87	HERB	GALIUM BOREALE	0.3	0.65	0.47
87	HERB	GEUM MACROPHYLLUM	0.9	0.95	0.92
87	HERB	GRASSES	1.0	8.90	4.95
87	HERB	LATHYRUS VENOSUS	0.5	0.25	0.38
87	HERB	MAIANTHEMUM CANADENSE	0.4	0.20	0.30
87	HERB	PETASITES PALMATUS	0.3	0.15	0.22
87	HERB	VIOLA SPP.	1.0	8.10	4.55

VEGETATION PARAMETERS FOR INDICATOR SPECIES
AT BURN SITES, SANDY RIVER WEST, 1985-1987

SITE=CONTROL BURN

YEAR	STRATA	SPECIES	FREQUENCY	COVER	ASSOCIATION VALUE
85	SHRUB	ROSA ACICULARIS	0.4	4.10	2.25
85	SHRUB	RUBUS IDAEUS	1.0	21.10	11.05
85	HERB	AQUILEGIA CANADENSIS	0.2	8.80	4.50
85	HERB	ASTER CILIOLATUS	0.2	2.30	1.25
85	HERB	CIRSIUM ARVENSE	0.9	6.85	3.87
85	HERB	CIRSIUM SPP.	0.2	0.60	0.40
85	HERB	EPILOBIUM ANGUSTIFOLIUM	0.6	0.80	0.70
85	HERB	EQUISETUM SYLVATICUM	0.8	2.40	1.60
85	HERB	FRAGARIA GLAUCA	0.5	4.15	2.32
85	HERB	GALIUM BOREALE	0.7	31.15	15.92
85	HERB	GRASSES	1.0	54.30	27.65
85	HERB	LATHYRUS VENOSUS	1.0	11.70	6.35
85	HERB	MAIANTHEMUM CANADENSE	0.1	0.55	0.32
85	HERB	PETASITES PALMATUS	0.1	0.05	0.07
85	HERB	VIOLA SPP.	0.5	1.75	1.13
86	SHRUB	ROSA ACICULARIS	0.4	3.40	1.90
86	SHRUB	RUBUS IDAEUS	0.9	9.25	5.07
86	HERB	AQUILEGIA CANADENSIS	0.2	0.60	0.40
86	HERB	ASTER CILIOLATUS	0.8	3.60	2.20
86	HERB	CIRSIUM ARVENSE	0.8	11.00	5.90
86	HERB	CIRSIUM SPP.	0.3	0.65	0.47
86	HERB	EPILOBIUM ANGUSTIFOLIUM	0.5	0.75	0.63
86	HERB	EQUISETUM SYLVATICUM	0.8	2.40	1.60
86	HERB	FRAGARIA GLAUCA	0.8	3.90	2.35
86	HERB	GALIUM BOREALE	0.8	35.20	18.00
86	HERB	GEUM MACROPHYLLUM	0.3	0.15	0.22
86	HERB	GRASSES	1.0	75.90	38.45
86	HERB	LATHYRUS VENOSUS	0.8	10.00	5.40
86	HERB	MAIANTHEMUM CANADENSE	0.4	1.20	0.80
86	HERB	PETASITES PALMATUS	0.1	0.05	0.07
87	SHRUB	ROSA ACICULARIS	0.5	1.25	0.88
87	SHRUB	RUBUS IDAEUS	0.8	4.10	2.45
87	HERB	AQUILEGIA CANADENSIS	0.1	0.55	0.32
87	HERB	ASTER CILIOLATUS	0.8	2.40	1.60
87	HERB	CIRSIUM ARVENSE	1.0	1.50	1.25
87	HERB	CIRSIUM SPP.	0.2	0.10	0.15
87	HERB	EPILOBIUM ANGUSTIFOLIUM	0.4	0.20	0.30
87	HERB	EQUISETUM SYLVATICUM	0.1	0.05	0.07
87	HERB	FRAGARIA GLAUCA	0.6	2.30	1.45
87	HERB	GALIUM BOREALE	0.6	17.10	8.85
87	HERB	GEUM MACROPHYLLUM	0.3	0.15	0.22
87	HERB	GRASSES	1.0	22.10	11.55
87	HERB	LATHYRUS VENOSUS	0.6	0.80	0.70
87	HERB	MAIANTHEMUM CANADENSE	0.2	0.60	0.40
87	HERB	PETASITES PALMATUS	0.1	0.05	0.07

APPENDIX B Density and relative density of thirteen birds species at Sandy River West, 1985-1987.

Appendix B

BIRD SURVEY RESULTS FOR INDICATOR SPECIES
(PER 40 HA) AT SANDY RIVER WEST, 1985-1987.

1985

		CONTROL ASPEN		TREATED ASPEN		CONTROL BURN		TREATED BURN	
		DENSITY PER 40 HA	RELATIVE DENSITY PER 40 HA	DENSITY PER 40 HA	RELATIVE DENSITY PER 40 HA	DENSITY PER 40 HA	RELATIVE DENSITY PER 40 HA	DENSITY PER 40 HA	RELATIVE DENSITY PER 40 HA
	SPECIES								
JUNE	ALDER FLYCATCHER	.	.	.	.	83.0	10.6	48.0	7.5
	BLACK AND WHITE WARBLER	6.0	1.2	16.0	3.5	.	.	.	.
	CHESTNUT-SIDED WARBLER	32.0	6.5	16.0	3.5	.	.	.	.
	CHIPPING SPARROW	58.0	11.8	22.0	4.8	26.0	3.3	48.0	7.5
	COMMON FLICKER	.	.	.	.	38.0	4.9	19.0	3.0
	COMMON YELLOW-THROATED WARBLER	38.0	7.7	134.0	29.1	198.0	25.4	157.0	24.4
	HOUSE WREN	.	.	.	.	64.0	8.2	6.0	0.9
	MOURNING WARBLER	173.0	35.1	48.0	10.4	83.0	10.6	99.0	15.4
	NASHVILLE WARBLER	32.0	6.5	29.0	6.3	0.0	0.0	0.0	0.0
	RED-EYED VIREO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SONG SPARROW	.	.	.	.	109.0	14.0	51.0	7.9
	TENNESSEE WARBLER	32.0	6.5	42.0	9.1	32.0	4.1	29.0	4.5
	WHITE-THROATED SPARROW	122.0	24.7	154.0	33.4	147.0	18.8	186.0	28.9

BIRD SURVEY RESULTS FOR INDICATOR SPECIES
(PER 40 HA) AT SANDY RIVER WEST, 1985-1987.

1986

		CONTROL ASPEN		TREATED ASPEN		CONTROL BURN		TREATED BURN	
		DENSITY PER 40 HA	RELATIVE DENSITY PER 40 HA	DENSITY PER 40 HA	RELATIVE DENSITY PER 40 HA	DENSITY PER 40 HA	RELATIVE DENSITY PER 40 HA	DENSITY PER 40 HA	RELATIVE DENSITY PER 40 HA
	SPECIES								
JUNE	ALDER FLYCATCHER	.	.	.	.	70.0	18.5	58.0	16.1
	BLACK AND WHITE WARBLER	45.0	13.5	6.0	2.9	.	.	.	.
	CHESTNUT-SIDED WARBLER	32.0	9.6	10.0	4.9	.	.	.	.
	CHIPPING SPARROW	13.0	3.9	10.0	4.9	45.0	11.9	38.0	10.5
	COMMON FLICKER	.	.	.	.	13.0	3.4	0.0	0.0
	COMMON YELLOW-THROATED WARBLER	19.0	5.7	35.0	17.1	122.0	32.3	67.0	18.6
	HOUSE WREN	.	.	.	.	19.0	5.0	6.0	1.7
	MOURNING WARBLER	90.0	27.0	61.0	29.8	13.0	3.4	74.0	20.5
	NASHVILLE WARBLER	32.0	9.6	35.0	17.1	13.0	3.4	13.0	3.6
	RED-EYED VIREO	38.0	11.4	13.0	6.3	0.0	0.0	22.0	6.1
	SONG SPARROW	.	.	.	.	45.0	11.9	42.0	11.6
	TENNESSEE WARBLER	0.0	0.0	0.0	0.0	6.0	1.6	3.0	0.8
	WHITE-THROATED SPARROW	64.0	19.2	35.0	17.1	32.0	8.5	38.0	10.5

BIRD SURVEY RESULTS FOR INDICATOR SPECIES
(PER 40 HA) AT SANDY RIVER WEST, 1985-1987.

1987

		CONTROL ASPEN		TREATED ASPEN		CONTROL BURN		TREATED BURN	
		DENSITY PER 40 HA	RELATIVE DENSITY PER 40 HA	DENSITY PER 40 HA	RELATIVE DENSITY PER 40 HA	DENSITY PER 40 HA	RELATIVE DENSITY PER 40 HA	DENSITY PER 40 HA	RELATIVE DENSITY PER 40 HA
	SPECIES								
JUNE	ALDER FLYCATCHER	.	.	.	.	44.8	10.4	60.8	16.1
	BLACK AND WHITE WARBLER	19.2	7.0	38.4	14.6	.	.	.	.
	CHESTNUT-SIDED WARBLER	25.6	9.3	16.0	6.1	.	.	.	.
	CHIPPING SPARROW	6.4	2.3	12.8	4.9	70.4	16.4	19.2	5.1
	COMMON FLICKER	.	.	.	.	0.0	0.0	0.0	0.0
	COMMON YELLOW-THROATED WARBLER	70.4	25.6	44.8	17.1	160.0	37.3	80.0	21.2
	HOUSE WREN	.	.	.	.	32.0	7.5	0.0	0.0
	MOURNING WARBLER	64.0	23.3	22.4	8.5	32.0	7.5	67.2	17.8
	NASHVILLE WARBLER	38.4	14.0	41.6	15.9	6.4	1.5	28.8	7.6
	RED-EYED VIREO	0.0	0.0	32.0	12.2	0.0	0.0	44.8	11.9
	SONG SPARROW	.	.	.	.	70.4	16.4	38.4	10.2
	TENNESSEE WARBLER	0.0	0.0	3.2	1.2	0.0	0.0	0.0	0.0
	WHITE-THROATED SPARROW	51.2	18.6	51.2	19.5	12.8	3.0	38.4	10.2

APPENDIX C Trapping results for seven small mammal species at Sandy River West, 1985-1987.

Appendix C

TRAPPING RESULTS FOR SEVEN COMMON SMALL MAMMALS
(PER 1000 TRAP NIGHTS) AT SANDY RIVER WEST, 1985-1987.

1985

TIME	SPECIES	CONTROL ASPEN CATCH PER 1000 TRAP NIGHTS	TREATED ASPEN CATCH PER 1000 TRAP NIGHTS	CONTROL BURN CATCH PER 1000 TRAP NIGHTS	TREATED BURN CATCH PER 1000 TRAP NIGHTS
PRE	ARCTIC SHREW	0.00	3.00	0.00	0.00
	BOREAL REDBACK VOLE	6.00	17.00	0.00	17.00
	DEER MOUSE	6.00	8.00	6.00	22.00
	LEAST CHIPMUNK	0.00	3.00	0.00	3.00
	MASKED SHREW	0.00	11.00	0.00	0.00
	MEADOW JUMPING MOUSE	8.00	3.00	3.00	14.00
	MEADOW VOLE	0.00	0.00	3.00	0.00
3 DAYS	ARCTIC SHREW	0.00	0.00	3.00	0.00
	BOREAL REDBACK VOLE	14.00	61.00	14.00	17.00
	DEER MOUSE	25.00	3.00	31.00	61.00
	LEAST CHIPMUNK	0.00	0.00	3.00	3.00
	MASKED SHREW	25.00	78.00	53.00	44.00
	MEADOW JUMPING MOUSE	14.00	11.00	6.00	8.00
	MEADOW VOLE	0.00	0.00	0.00	0.00
FALL	ARCTIC SHREW	0.00	0.00	8.00	0.00
	BOREAL REDBACK VOLE	3.00	25.00	8.00	25.00
	DEER MOUSE	56.00	17.00	42.00	56.00
	LEAST CHIPMUNK	3.00	0.00	0.00	0.00
	MASKED SHREW	14.00	47.00	42.00	3.00
	MEADOW JUMPING MOUSE	0.00	0.00	11.00	3.00
	MEADOW VOLE	0.00	0.00	0.00	0.00

TRAPPING RESULTS FOR SEVEN COMMON SMALL MAMMALS
(PER 1000 TRAP NIGHTS) AT SANDY RIVER WEST, 1985-1987.

1986

TIME	SPECIES	CONTROL ASPEN CATCH PER 1000 TRAP NIGHTS	TREATED ASPEN CATCH PER 1000 TRAP NIGHTS	CONTROL BURN CATCH PER 1000 TRAP NIGHTS	TREATED BURN CATCH PER 1000 TRAP NIGHTS
PRE	ARCTIC SHREW	0.00	8.00	3.00	0.00
	BOREAL REDBACK VOLE	56.00	44.00	33.00	39.00
	DEER MOUSE	42.00	6.00	17.00	28.00
	LEAST CHIPMUNK	0.00	0.00	0.00	0.00
	MASKED SHREW	28.00	14.00	6.00	39.00
	MEADOW JUMPING MOUSE	28.00	8.00	14.00	17.00
	MEADOW VOLE	0.00	3.00	17.00	3.00
3 DAYS	ARCTIC SHREW	0.00	11.00	3.00	0.00
	BOREAL REDBACK VOLE	53.00	61.00	42.00	108.00
	DEER MOUSE	42.00	8.00	17.00	14.00
	LEAST CHIPMUNK	0.00	0.00	0.00	3.00
	MASKED SHREW	56.00	56.00	83.00	80.00
	MEADOW JUMPING MOUSE	19.00	25.00	14.00	8.00
	MEADOW VOLE	0.00	0.00	3.00	6.00
FALL	ARCTIC SHREW	0.00	17.00	14.00	0.00
	BOREAL REDBACK VOLE	78.00	97.00	86.00	125.00
	DEER MOUSE	25.00	6.00	15.00	17.00
	LEAST CHIPMUNK	0.00	0.00	0.00	0.00
	MASKED SHREW	86.00	92.00	75.00	86.00
	MEADOW JUMPING MOUSE	3.00	11.00	3.00	6.00
	MEADOW VOLE	0.00	3.00	3.00	0.00

TRAPPING RESULTS FOR SEVEN COMMON SMALL MAMMALS
(PER 1000 TRAP NIGHTS) AT SANDY RIVER WEST, 1985-1987.

1987

TIME	SPECIES	CONTROL ASPEN CATCH PER 1000 TRAP NIGHTS	TREATED ASPEN CATCH PER 1000 TRAP NIGHTS	CONTROL BURN CATCH PER 1000 TRAP NIGHTS	TREATED BURN CATCH PER 1000 TRAP NIGHTS
PRE	ARCTIC SHREW	3.00	0.00	0.00	0.00
	BOREAL REDBACK VOLE	33.00	11.00	31.00	36.00
	DEER MOUSE	47.00	6.00	17.00	8.00
	LEAST CHIPMUNK	3.00	6.00	0.00	0.00
	MASKED SHREW	0.00	3.00	14.00	11.00
	MEADOW JUMPING MOUSE	22.00	3.00	11.00	25.00
	MEADOW VOLE	33.00	22.00	122.00	44.00
FALL	ARCTIC SHREW	0.00	3.00	11.00	3.00
	BOREAL REDBACK VOLE	17.00	22.00	19.00	22.00
	DEER MOUSE	39.00	8.00	3.00	8.00
	LEAST CHIPMUNK	0.00	0.00	0.00	0.00
	MASKED SHREW	6.00	22.00	8.00	25.00
	MEADOW JUMPING MOUSE	0.00	0.00	0.00	0.00
	MEADOW VOLE	17.00	28.00	42.00	11.00

APPENDIX D Environmental conditions and number of ungulate tracks at Sandy River West, 1985-1988.

Appendix D

SNOW CONDITIONS AND NUMBER OF UNGULATE TRACKS RECORDED FOR THREE WINTER SURVEYS, 1985/1986, 1986/1987, 1987/1988, AT SANDY RIVER WEST

SEASON 1985/1986

YEAR MONTH DAY	SITE	SNOW DEPTH (CM)	CRUST HARDNESS (G/CM2)	CRUST DEPTH (CM)	TEMPERATURE (°C)	NUMBER DEER TRACKS	NUMBER MOOSE TRACKS
851206	CONTROL ASPEN	32.70	0.00	.	-15.00	8.00	0.00
	CONTROL BURN	37.50	0.00	.	-15.00	6.00	0.00
	TREATED ASPEN	36.40	0.00	.	-15.00	3.00	0.00
	TREATED BURN	31.50	0.00	.	-15.00	0.00	0.00
860127	CONTROL ASPEN	44.80	44.00	.	-18.00	0.00	0.00
	CONTROL BURN	52.00	72.00	.	-18.00	0.00	0.00
	TREATED ASPEN	51.60	69.00	.	-18.00	0.00	0.00
	TREATED BURN	41.80	190.00	.	-18.00	0.00	0.00
860130	CONTROL ASPEN	42.60	30.00	.	-19.00	0.00	0.00
	CONTROL BURN	49.60	85.00	.	-19.00	0.00	0.00
	TREATED ASPEN	49.50	58.00	.	-19.00	0.00	0.00
	TREATED BURN	39.70	76.00	.	-19.00	0.00	0.00

SNOW CONDITIONS AND NUMBER OF UNGULATE TRACKS RECORDED FOR THREE WINTER SURVEYS, 1985/1986, 1986/1987, 1987/1988, AT SANDY RIVER WEST

SEASON 1986/1987

YEAR MONTH DAY	SITE	SNOW DEPTH (CM)	CRUST HARDNESS (G/CM2)	CRUST DEPTH (CM)	TEMPERATURE (°C)	NUMBER DEER TRACKS	NUMBER MOOSE TRACKS
861121	CONTROL ASPEN	35.70	0.00	0.00	0.00	13.00	0.00
	CONTROL BURN	42.80	0.00	0.00	0.00	2.00	0.00
	TREATED ASPEN	47.30	0.00	0.00	0.00	1.00	0.00
	TREATED BURN	36.90	0.00	0.00	0.00	1.00	0.00
861126	CONTROL ASPEN	31.20	90.30	.	0.00	3.00	0.00
	CONTROL BURN	35.70	75.60	.	0.00	6.00	0.00
	TREATED ASPEN	42.00	67.90	.	0.00	0.00	0.00
	TREATED BURN	31.90	94.00	.	0.00	0.00	0.00
861205	CONTROL ASPEN	35.70	69.50	5.00	-10.00	0.00	0.00
	CONTROL BURN	39.90	63.00	7.50	-10.00	0.00	0.00
	TREATED ASPEN	48.40	83.00	7.50	-10.00	1.00	0.00
	TREATED BURN	38.60	127.00	7.50	-10.00	0.00	1.00
861212	CONTROL ASPEN	42.10	63.00	5.00	-20.00	0.00	0.00
	CONTROL BURN	46.90	79.00	8.00	-20.00	6.00	0.00
	TREATED ASPEN	53.90	81.00	8.00	-20.00	0.00	11.00
	TREATED BURN	40.60	81.00	8.00	-20.00	0.00	0.00
870204	CONTROL ASPEN	41.30	68.00	12.10	-10.00	0.00	0.00
	CONTROL BURN	44.60	74.00	13.20	-10.00	1.00	2.00
	TREATED ASPEN	51.60	79.50	14.00	-10.00	0.00	0.00
	TREATED BURN	32.70	66.00	11.70	-10.00	0.00	2.00
870218	CONTROL ASPEN	46.30	28.00	10.00	-5.00	0.00	0.00
	CONTROL BURN	48.50	42.00	13.60	-5.00	0.00	0.00
	TREATED ASPEN	55.90	44.00	16.00	-5.00	0.00	0.00
	TREATED BURN	37.90	58.00	13.50	-5.00	0.00	0.00

SNOW CONDITIONS AND NUMBER OF UNGULATE TRACKS RECORDED FOR THREE WINTER SURVEYS, 1985/1986, 1986/1987, 1987/1988, AT SANDY RIVER WEST

SEASON 1987/1988

YEAR MONTH DAY	SITE	SNOW DEPTH (CM)	CRUST HARDNESS (G/CM2)	CRUST DEPTH (CM)	TEMPERATURE (°C)	NUMBER DEER TRACKS	NUMBER MOOSE TRACKS
871214	CONTROL ASPEN	17.20	0.00	0.00	-10.00	4.00	0.00
	CONTROL BURN	26.80	0.00	0.00	-10.00	2.00	0.00
	TREATED ASPEN	25.30	0.00	0.00	-10.00	0.00	0.00
	TREATED BURN	23.90	0.00	0.00	-10.00	6.00	0.00
880121	CONTROL ASPEN	23.50	0.00	0.00	-10.00	1.00	0.00
	CONTROL BURN	29.00	0.00	0.00	-10.00	0.00	0.00
	TREATED ASPEN	26.50	0.00	0.00	-10.00	0.00	0.00
	TREATED BURN	24.40	0.00	0.00	-10.00	0.00	0.00
880125	CONTROL ASPEN	29.10	0.00	0.00	-25.00	0.00	0.00
	CONTROL BURN	34.20	0.00	0.00	-25.00	0.00	0.00
	TREATED ASPEN	32.50	0.00	0.00	-25.00	0.00	0.00
	TREATED BURN	29.20	0.00	0.00	-25.00	0.00	0.00
880202	CONTROL ASPEN	37.90	0.00	0.00	-22.00	3.00	0.00
	CONTROL BURN	36.40	0.00	0.00	-22.00	0.00	0.00
	TREATED ASPEN	34.30	0.00	0.00	-22.00	2.00	0.00
	TREATED BURN	32.60	0.00	0.00	-22.00	0.00	0.00
880209	CONTROL ASPEN	31.40	0.00	0.00	-26.00	0.00	0.00
	CONTROL BURN	35.40	23.00	0.00	-26.00	0.00	0.00
	TREATED ASPEN	33.90	0.00	0.00	-26.00	0.00	0.00
	TREATED BURN	32.30	3.00	0.00	-26.00	0.00	0.00
880218	CONTROL ASPEN	38.50	7.50	10.00	-5.00	0.00	0.00
	CONTROL BURN	43.20	22.40	10.00	-5.00	0.00	0.00
	TREATED ASPEN	42.30	13.50	10.00	-5.00	3.00	0.00
	TREATED BURN	36.30	8.50	10.00	-5.00	0.00	0.00